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EFFECTS OF DIFFERENT CARBURETOR SETTINGS ON THE PERFORMANCE CHARACTERISTICS OF SOME MAKES OF AUTOMOBILE ENGINES USING ALCOHOL AS MOTOR FUEL[1]

A. L. TEODORO
Of the Department of Agricultural Engineering

WITH EIGHT TEXT FIGURES

The practice of using a needle valve for regulating the quantity of fuel that leaves the carburetor of some makes of automobile engines has been discontinued since 1930. Then fixed jets were employed, and several optional sizes were offered to suit engine requirements in fuel economy and power. At present, in some types of carburetors, as many as six sizes of main metering jets are available, whereas in others, only three optional sizes provide specific satisfactory operations for maximum power, optimum fuel economy, and intermediate needs. Big metering jets are generally used for trucks hauling very heavy loads, and small jets, for cars and transportation trucks demanding strict fuel economy to be operated profitably. Intermediate settings are used by many transportation companies and by owners of private cars needing quick accelerations and medium power requirements.

The writer presents the effects of different carburetor settings on the performance characteristics of some makes of automobile engines when alcohol and some alcohol-gasoline mixtures are used as fuel.

MATERIALS

A six cylinder engine and an eight cylinder engine with the following specifications were used:

Cylinder—6, bore and stroke—3-5/16″ × 4″, compression ratios —5.0:1 and 5.7:1, and R.P.M.—2750.

Cylinder—8, bore and stroke—3-1/16″ × 3-3/4″, compression ratios—6.3:1 and 7.5:1, type V-90 degree crank shaft, and R.P.M. —3800.

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[1] Experiment Station contribution No. 1384.

Dynamometer—standard hydraulic absorption type and size, D.P. × 4 (Heenan & Froude).

Fuel measuring device—Zenith mileage tester with capacity, $\frac{1}{10}$ U. S. gallon.

Fuels—Alkohl motor fuel,[2] commercial gasoline, 10 per cent alcohol-gasoline mixture,[3] and 20 per cent alcohol-gasoline mixture.[4]

EXPERIMENTAL

Two series of tests A and B were conducted. Bench tests were carried out in series A, and road tests, in series B.

The bench tests included the determination at different speeds of: (*1*) maximum brake horsepower, and (*2*) fuel economy at maximum, at ¾, at ½, and at ¼ maximum brake horsepower at each of these speeds. The speed varied at 200 R.P.M. intervals from 400 to 2200 R.P.M. The maximum torque was determined during the maximum brake horsepower runs. For runs at ¾, ½, and ¼ maximum brake horsepower at the same speed, the torque was set at ¾, ½, and ¼ the maximum for this speed, by throttling.

Road tests for a nearly level road and for winding hilly sections were conducted. A large portion of the level road was poorly macadamized, and the rest, asphalted. There were some grades, which varied from 1 to 3 per cent, along this route. Only a small section of the hilly route was asphalted; the rest, in fair condition, was macadamized, narrow, and winding, and had grades varying from 1 to 5 per cent.

Six cylinder engine. The engine was fed with gasoline in one group of bench tests with compression ratios 5.0:1 and 5.7:1. Only the most economical metering jet was used. Another group of tests with Alkohl as motor fuel was carried out with a compression ratio of 5.7:1, using maximum power adjustment, intermediate adjustment, and optimum fuel economy adjustment. The largest optional size for the main metering jet and the smallest optional size for the metering rod were used for maximum power adjustment. The smallest optional size for the main metering jet and the largest optional size for the metering rod were used in the test giving optimum fuel eco-

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[2] 100 parts by volume of 190° proof ethyl alcohol + 5 parts by volume of commercial gasoline. Sp. gr. = 0.810.

[3] 10 parts by volume of dehydrated alcohol + 90 parts by volume of commercial gasoline. Sp. gr. = 0.754.

[4] 20 parts by volume of dehydrated alcohol + 80 parts by volume of commercial gasoline. Sp. gr. = 0.756.

nomy. Intermediate sizes for the jet and the rod were used in the tests grouped under intermediate adjustment.

Two groups of road tests were run. In one, Alkohl motor fuel was used at compression ratios of 5.0:1 and 5.7:1, and gasoline at a compression ratio of 5.0:1. The carburetor was adjusted for maximum power setting in both cases. In the other group with a compression ratio of 5.0:1, gasoline was compared with Alkohl motor fuel. The carburetor in the former was adjusted for optimum fuel economy, and in the latter, for maximum power, optimum fuel economy, and medium settings.

Eight cylinder engine. Gasoline, 10 per cent alcohol-gasoline mixture, and 20 per cent alcohol-gasoline mixture were used in the bench tests. Runs were made on full throttle only and at a compression ratio of 6.3:1. Three sizes of main metering jets were used. In one group of the road tests, gasoline and 10 per cent alcohol-gasoline mixtures were compared, with compression ratios of 6.3:1 and 7.5:1. Only the most economical jet was used in these tests. In the other group, gasoline and 20 per cent alcohol-gasoline mixtures were compared, with a maximum power jet, an optimum economical jet, and a medium jet setting used at a compression ratio of 6.3:1.

RESULTS AND DISCUSSION

Series A

The results of the bench tests with gasoline in the six cylinder engine showed the following (fig. 1):

1. The fuel consumption at a compression ratio of 5.7:1 was definitely lower than at 5.0:1. It gave about 15 per cent less at full load, 4 per cent less at three-fourths load, and 8 per cent less at half load. The most economical consumption was obtained on three-fourths load at a compression ratio of 5.0:1 and on full load at 5.7:1.

2. The maximum power developed was practically the same at high and low compression ratios.

3. With a high compression ratio, incipient detonation occurred at high loads and on accelerating from low to high speed. There was no sign of detonation at a low compression ratio.

4. Optimum fuel economy at different loads occurred between the speedometer speeds of 35 and 42 kilometers per hour or between the engine speeds of 1350 and 1600 R.P.M.

The results of the tests with Alkohl motor fuel on the six cylinder engine at a compression ratio of 5.7:1 point to the following (figs. 2, 3, 4, 5):

1. The power developed at different speeds on full throttle was higher at from 800 R.P.M. to 2000 R.P.M. with maximum power adjustment than with intermediate or with maximum fuel economy settings. The difference varied from a fraction of a horsepower to a little over one horsepower between 1000 and 1700 R.P.M. From 1700 to 2000 R.P.M. the difference in power decreased gradually.

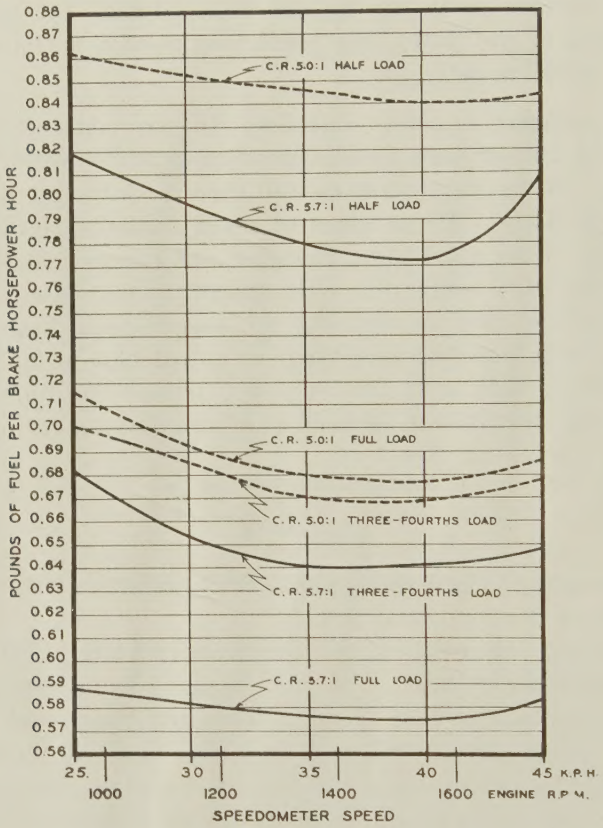

Fig. 1.—Fuel economy curve of a six cylinder engine using gasoline at compression ratios 5.0:1 and 5.7:1.

Beyond 2000 R.P.M. practically the same power was obtained with the three settings. Short tests with main jets bigger than the one used for maximum power setting resulted in increased fuel consumption without any increase in the power developed. In some cases, the maximum power developed decreased by about ten per cent owing to very rich mixture. It was easily possible to double the fuel

consumption at maximum speed on full throttle by using an over-size jet without the engine showing signs of over-rich mixture.

2. The difference in fuel economy between optimum economical setting and maximum power setting was about 8 per cent at full throttle, 3 per cent at three-fourths load, 1 per cent at one-half load, and 3 per cent at one-fourth load.

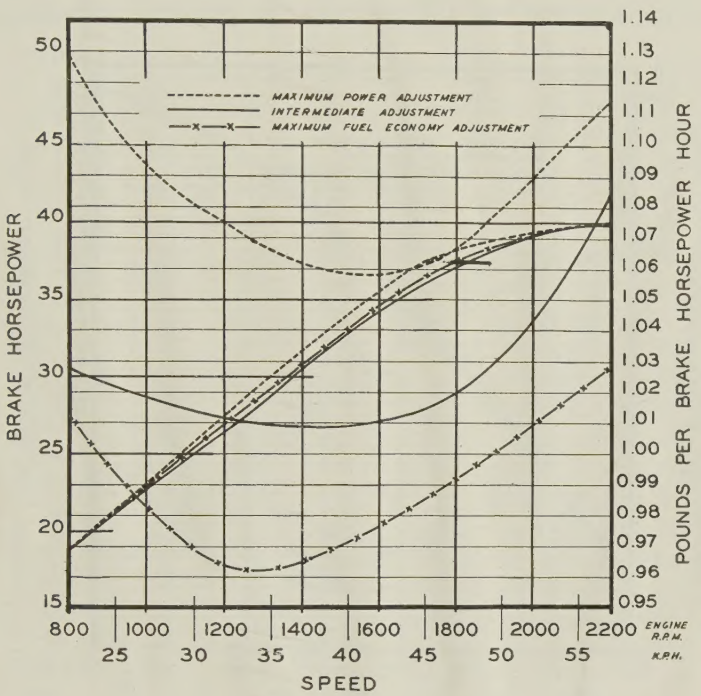

Fig. 2.—Performance curves at full throttle of a six cylinder engine using Alkohl motor fuel with different carburetor settings. Compression ratio 5.7:1.

3. The most economical speed at various loads for all three settings was from 1300 R.P.M. to 1700 R.P.M. This was equivalent to a speedometer speed of from 35 km. to 45 km. per hour.

The bench tests on the eight cylinder engine gave the following results (figs. 6 and 7):

1. The maximum power developed at different speeds was highest with the 10 per cent mixture with an intermediate size main metering jet.

2. Fuel economy was optimum with the 20 per cent mixture with the most economical jet. The power developed with this fuel

was slightly lower than that obtained from gasoline with the most economical jet.

3. With the fuel economy of gasoline with the most economical jet considered as 100 per cent, the relative percentages for the other fuels are approximately 90 per cent for the 20 per cent mixture with the most economical jet, 97 per cent for the 10 per cent mixture with the most economical jet, 106 per cent for the 10 per cent mixture with the medium size jet, 107 per cent for gasoline with the medium

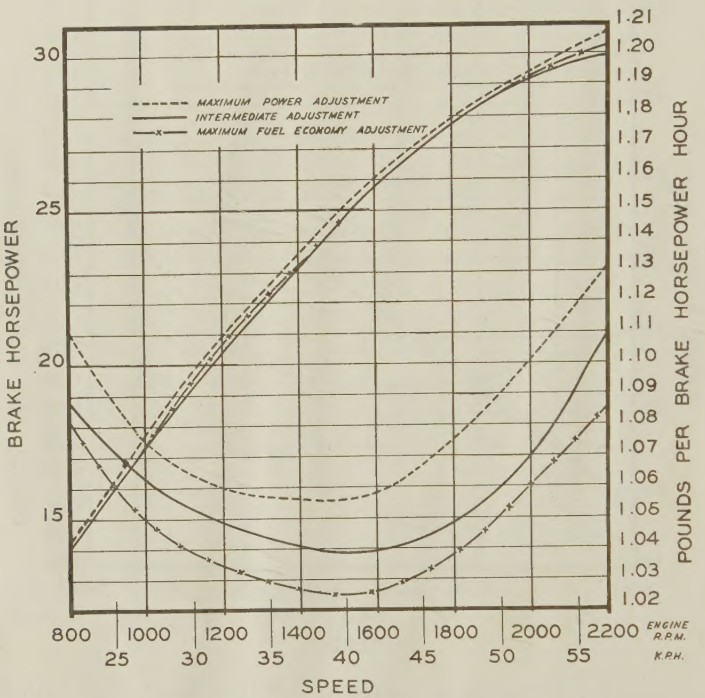

Fig. 3.—Performance curves at three-fourths load of a six cylinder engine using Alkohl motor fuel with different carburetor settings. Compression ratio 5.7:1.

size jet, and 110 per cent for gasoline and for the 10 per cent mixture with the maximum power jet.

Series B

A study of table 1 shows the following:

1. With the maximum power setting in the six cylinder engine, the mileage obtained for gasoline was 6.3 kilometers per liter (15 miles per gallon), and for Alkohl motor fuel, 4.6 kilometers per liter (10.9 miles per gallon) at a compression ratio of 5.7:1, and 4.0 kilo-

meters per liter (9.5 miles per gallon) at a compression ratio of 5.0:1. With gasoline as 100 per cent, the relative values for Alkohl motor fuel were 73 per cent at a compression ratio of 5.7:1 and 63.5 per cent at a compression ratio of 5.0:1.

2. With the economical jet in the eight cylinder engine, the mileage obtained for gasoline was 7.7 kilometers per liter (18 miles per gallon) at a compression ratio of 6.3:1 and 8.6 kilometers per liter (20.5 miles per gallon) at a compression ratio of 7.5:1. With the

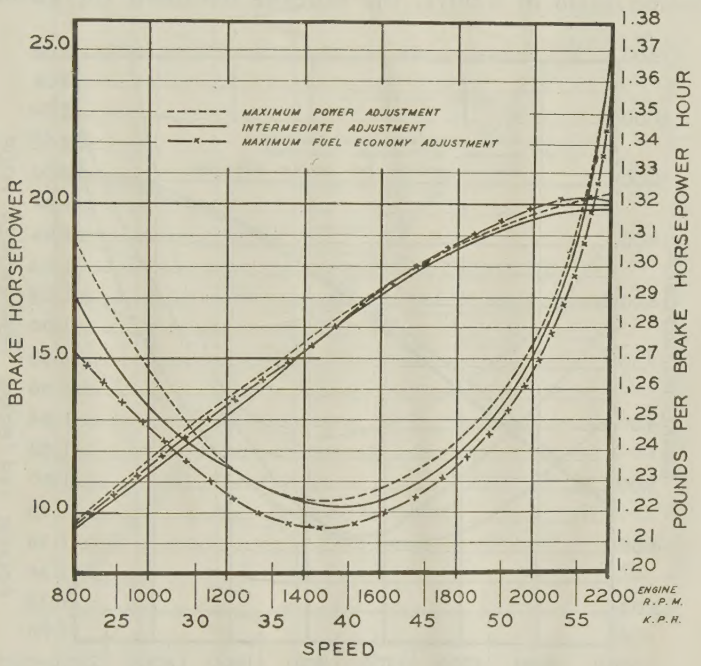

Fig. 4.—Performance curves at one-half load of a six cylinder engine using Alkohl motor fuel with different carburetor settings. Compression ratio 5.7:1.

10 per cent mixture, the mileage was 7.8 kilometers per liter (18.4 miles per gallon) at a compression ratio of 6.3:1 and 8.8 kilometers per liter (20.6 miles per gallon) at a compression ratio of 7.5:1. At an engine compression ratio of 6.3:1 and with gasoline as 100 per cent, the relative values at a compression ratio of 7.5:1 were 111.6 per cent for gasoline and 114.2 per cent for the 10 per cent mixture. The 10 per cent mixture rated 101.2 per cent at a compression ratio of 6.3:1.

3. The six cylinder engine evidenced very little detonation when tested at a speed of 45 kilometers per hour with a compression ratio

of 5.7:1. The eight cylinder engine, however, detonated badly on turning corners and occasionally at a constant speed of 45 kilometers per hour when gasoline was used at a compression ratio of 7.5:1. No evidence of detonation occurred when the 10 per cent mixture was used.

The following results were indicated during the road tests with variable carburetor adjustments (table 2):

1. With the most economical jet in the six-cylinder engine at a compression ratio of 5.00:1, the mileage obtained for gasoline was

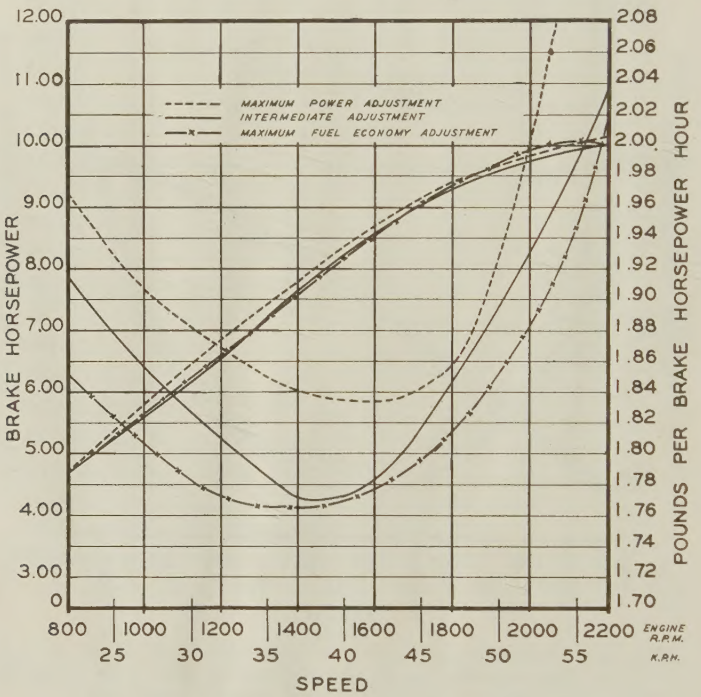

Fig. 5.—Performance curves at one-fourth load of a six cylinder engine using Alkohl motor fuel with different carburetor settings. Compression ratio 5.7:1.

7.5 kilometers per liter (17.7 miles per gallon) and for Alkohl motor fuel 4.8 kilometers per liter (11.4 miles per gallon). With this setting for gasoline as 100 per cent, the relative percentages with the medium and the power jet settings were, respectively, 63.6 and 61.9.

2. At a compression ratio of 6.3:1, the relative efficiencies for the eight cylinder engine were:

a. With the most economical jet setting for gasoline as 100 per cent, the values obtained for medium setting and power setting were,

respectively, 92.8 and 91.6. The 20 per cent mixture rated 109.1 per cent for the most economical setting, 98.7 per cent for the medium setting, and 95.8 per cent for the power setting.

b. With the medium setting for gasoline as 100 per cent, the power jet setting rated about 1.3 per cent less and the economical setting, about 7.8 per cent more. The 20 per cent mixture rated 103.6 per cent at power jet setting and 117.7 per cent at economical setting.

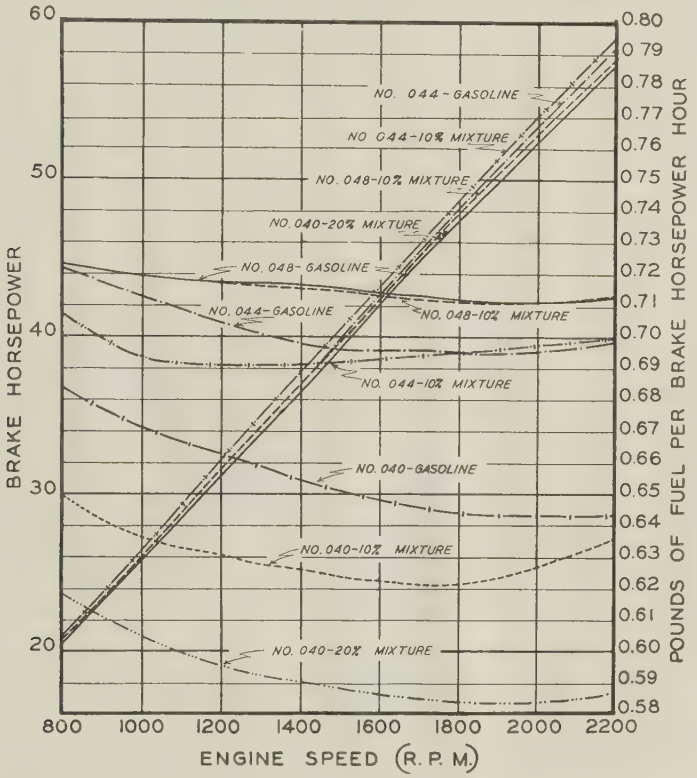

Fig. 6.—Performance curves at full load of an eight cylinder engine using different fuels with different carburetor settings. Compression ratio 6.3:1.

c. With the power setting for gasoline as 100 per cent, the medium and economical setting exceeded this value by 1.3 and 9.1 per cent, respectively. The 20 per cent mixture rated 4.9 per cent more at the power setting, 7.8 per cent more at the medium setting, and 19.3 per cent more at the economical setting.

Different optional sizes of jets are provided in different makes of carburetors to furnish satisfactory adjustments as regards fuel

economy and power developed. In temperate countries, the need for various sizes could not very well be avoided on account of the changes in weather conditions. With gasoline as motor fuel, one cannot expect a very constant, efficient, and satisfactory engine per-

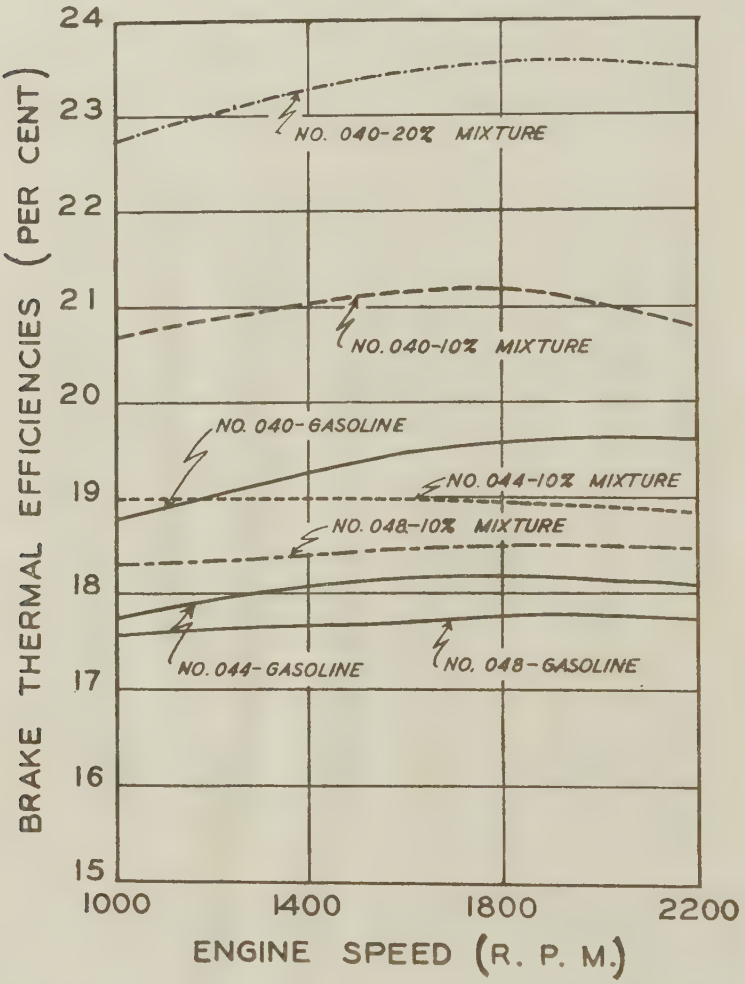

Fig. 7.—Brake thermal efficiencies at different speeds and at full throttle of an eight cylinder engine using different fuels and different carburetor settings. Compression ratio 6.3:1.

formance during the four seasons of the year without some kinds of carburetor adjustment to suit the weather. In the Philippines, the effects of weather on carburetion are not so marked as in temperate

countries, especially when gasoline is used. With alcohol, however, varied performances may be obtained when it is used either in nearly straight form or in an admixture with gasoline.

The results of the tests given in this paper with gasoline definitely show that optimum fuel economy can be obtained only with a jet that gives a slightly lean mixture. This setting leads to the development of power slightly smaller than the standard given by the factory for the engine tested. Engine operation at this setting is characterized by slow acceleration and by fuel knock at high loads, the latter occurring greatly at a high compression ratio. The setting that gave maximum power needed jets that gave a slightly rich mixture.

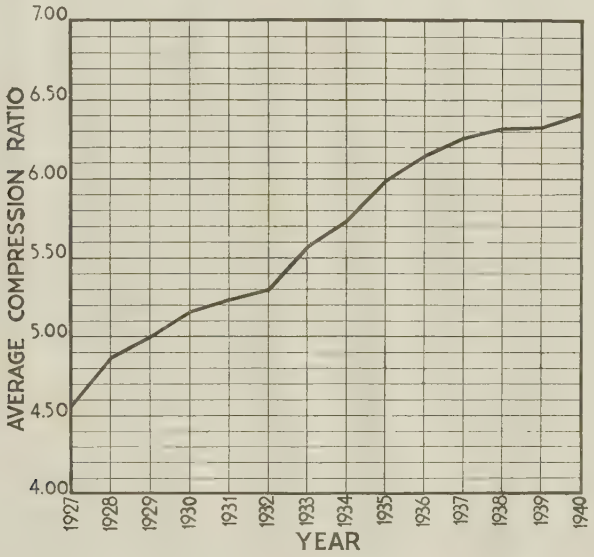

Fig. 8.—Trend of compression ratio used in automobile engines from 1927 to 1940.

With alcohol as motor fuel, more varied results than with gasoline may be obtained with different carburetor adjustments, because not only less air is required by alcohol than by gasoline for the complete combustion of the fuel, but also the range of composition over which the mixture is explosive is greater. The results of many tests using nearly straight alcohol varied from having very limited power developed with small jets to having too much fuel consumed at a certain maximum power with large jets. These results point to the necessity of adjusting the carburetor carefully whenever alcohol is used. The tests with mixtures of dehydrated alcohol and gasoline

indicated a varied fuel consumption ratio compared with gasoline, depending upon the size of jet used. The good effect of alcohol as an anti-detonating substance was definitely demonstrated, especially with a high compression ratio.

SUMMARY AND CONCLUSIONS

1. With gasoline as fuel the differences in fuel consumption between optimum economical carburetor setting and maximum power setting are approximately 5 to 8 per cent at full throttle and 1 to 3 per cent at fractional loads. The difference in power developed hardly exceeded 3 per cent.

Detonation was more evident in adjustments giving lean mixtures than in those giving rich.

2. Maximum power setting with nearly straight alcohol gave about 10 per cent more power than the maximum that could be developed with gasoline. This was done at the expense of a fuel consumption ratio (compared with gasoline by weight) varying from 1.4:1 to 1.7:1. It was easily possible to double the consumption of alcohol without increasing the power developed when a certain maximum load was reached.

The most economical adjustment that could be obtained was one giving a fuel consumption ratio of 1.27:1 (compared with gasoline by weight) and a maximum load of about 5 per cent less than the standard set by the engine manufacturer.

There was no evidence of detonation when nearly straight alcohol was used.

3. The 10 per cent alcohol-gasoline mixture gave as efficient running as gasoline and developed about 5 per cent more power with the same economical adjustment. With medium setting, the engine not only developed 10 per cent more power but also consumed 5 to 7 per cent less fuel than gasoline.

4. The 20 per cent alcohol-gasoline mixture gave less fuel consumption than gasoline at economical setting but developed about 3 per cent less power. The difference in fuel economy varied from 3 per cent to as high as 20 per cent, depending upon the jet used.

5. There was no evidence of detonation when the alcohol-gasoline mixtures were used under any carburetor settings. Acceleration was slightly sluggish when the 20 per cent mixture was tested with the most economical jet.

6. Better results in fuel economy and power were obtained with alcohol and alcohol-gasoline mixtures at a high compression ratio.

Gasoline, on the other hand, detonated badly, developed less maximum power, but gave slightly better fuel economy at certain loads with a high compression ratio than with a low.

7. The present trend of compression ratio used in automobile engines (fig. 8) favors the utilization of alcohol and alcohol-gasoline mixtures as fuel.

TABLE 1

Results of road tests with low and high compression heads

Engine tested	Six cylinder (Maximum power adjustment)			Eight cylinder (Economical jet)			
Fuel used	Alkohl	Motor Fuel	Gasoline	Gasoline		10 per cent mixture	
Compression ratio	5.0:1	5.7:1	5.0:1	7.5:1 [a]	6.3:1	7.5:1	6.3:1
Distance covered (km.)	257.0	208.0	228	80	50	60	50
Fuel consumption (average)							
Km. per liter	4.0	4.6	6.3	8.6	7.7	8.8	7.8
Miles per gallon	9.5	10.9	15.0	20.5	18.0	20.6	18.4
Ton km. per liter	13.1	15.1	20.7	14.0	12.5	14.3	12.7
Ton mile per gallon	31.2	35.7	49.2	33.4	29.3	33.6	30.0
Rating (per cent)	63.5	73.0	100.0	111.6	100.0	114.2	101.2
Speed (km. per hour)	45.0	45.0	45.0	45.0	45.0	45.0	45.0

[a] Engine detonated badly on rounding curves and in going up a hill with about five per cent grade.

TABLE 2

Results of road[a] tests with different carburetor adjustments

AVERAGE MILEAGE OBTAINED	KIND OF JET	SIX CYLINDER (COMPRESSION RATIO 5.0 : 1)				EIGHT CYLINDER (COMPRESSION RATIO 6.3 : 1)			
		Km./liter		Mi./gallon		Km./liter		Mi./gallon	
		Gasoline	Alkohl	Gasoline	Alkohl	Gasoline	20 per cent Mixture	Gasoline	20 per cent Mixture
	Power jet		4.66		10.96	7.07	7.41	16.62	17.42
	Medium jet		4.79		11.26	7.16	7.62	16.83	17.93
	Most economical jet	7.53	4.86	17.7	11.42	7.72	8.43	18.15	19.83

EFFICIENCY RATIO BASED ON MILEAGE		SIX CYLINDER (COMPRESSION RATIO 5.0 : 1)		EIGHT CYLINDER (COMPRESSION RATIO 6.3 : 1)					
		Gasoline	Alkohl	Gasoline	20 per cent Mixture	Gasoline	20 per cent Mixture	Gasoline	20 per cent Mixture
	Power jet		61.9	91.6	95.8	98.7	103.6	100.0	104.9
	Medium jet		63.6	92.8	98.7	100.0	106.5	101.3	107.8
	Most economical jet	100.0	64.6	100.0	109.1	107.8	117.7	109.1	119.3

[a] Car speed was 45–47 km. per hour.

A STUDY OF THE RELATION BETWEEN LENGTH OF STORAGE OF CORMS AND MATURITY AND YIELD OF GLADIOLUS [1]

VICENTE M. DAWIS AND MANUEL A. AARON
Of the Department of Agronomy

Until sufficient gladiolus corms are raised here comparable in quality to those brought in from other countries, the Philippines must continue importing them in large quantities. The demand for propagating material for this rapidly expanding flower crop is growing steadily. Since it is not convenient to purchase fresh corms from foreign countries regularly, the growers should know how long gladiolus corms may be kept under conditions prevailing in the Philippines.

Where facilities for cold storage are available, placing the gladiolus corms at temperatures between five and ten degrees centigrade considerably prolongs the keeping quality of the propagating material. It is generally recommended for gladiolus (Denny, 1936, 1937; Fairburn, 1934; Laurie and Mann, 1926; Floyd, 1928; Loomis and Evans, 1928; and Weinard and Decker, 1930). In many places in the Philippines, however, cold storage can not be obtained; hence the common way of storing corms at room temperature in the open will have to be used.

Denny (1938) reported having kept gladiolus corms for six months by storing the recently harvested corms in moist soil at room temperature (27°C.). He obtained better results this way than by storing them in air.

Objects of the present work

The objects of the present work were: (*a*) To find out how long corms of gladiolus in common storage at room temperature may be kept in good condition for planting without any treatment, (*b*) to compare the germination of corms and the monthly yield of flowers of each class of corms, and (*c*) to compare the production of corms and cormlets by each class of corms in monthly plantings.

[1] Experiment Station contribution No. 1385. Read before the Los Baños Biological Club on December 14, 1939.

Time and place of the present work

The work was performed from June, 1935, to April, 1937, in the floriculture garden and field of the Department of Agronomy of the College.

MATERIALS AND METHODS

Planting materials

An unnamed variety of gladiolus with yellow flowers was used in the experiment. This was given by Dr. Forman T. McLean, formerly of the Department of Agricultural Botany of this College, to Dr. Eduardo Quisumbing, who in turn gave a few corms to the Department of Agronomy. After several years of multiplication, sufficient corms were obtained for experimental purposes.

In the 1935-1936 season, 2510 corms were planted. They were measured with a caliper and classified into first, second, third, fourth, and fifth classes, according to size.

The classes, based on Rockwell's (1927) classification, are as follows:

Diameters in centimeters	*Classes*
3.7 or over	First
3.1 to 3.6	Second
2.5 to 3.0	Third
1.9 to 2.4	Fourth
1.3 to 1.8	Fifth

As plants from corms with diameters smaller than 1.3 cm. may or may not flower, they were not used in the experiments.

After the corms had been classified, each class was divided into twelve lots except the first class in the first year planting, which was not divided. All in the second year planting were divided into eight. Every month a lot was planted.

In the first planting, 50 corms of the first class were used, 50 of the second, 100 of the third, 40 of the fourth, and 15 of the fifth. First class corms were used only in the first planting. In the following plantings, the same classes and numbers of corms were used.

With the results of the first season planting as a guide, more corms were grown in December, 1935, to supply corms for the 1936-1937 season. This culture was harvested on April 1, 1936. The number amounted to 1272 corms. These were divided into eight lots, each with 120 first class corms, 20 second class, 8 third class, 7 fourth class, and 4 fifth class.

According to the results of the first year monthly plantings, corms remain viable only up to the seventh month; therefore, material

for the second year plantings was divided into eight lots only. By this arrangement more corms were available for planting than if they had been divided into twelve lots.

The land used and its preparation

The land used measured 369 square meters. It was divided into 42 lots, 7 meters by 1, with a path one-fourth meter wide between the plots. It had been a lawn and was plowed under. Its soil, heavy clay, was well drained.

The land was plowed with a native plow twice at intervals of one week and harrowed with a bamboo harrow once after each plowing. One week after it had been divided into plots and immediately before the corms were planted, it was dug up with a spading fork and raked in order to pulverize the soil and level the surface.

Planting

One lot divided into five plots corresponding to five classes of corms was planted every month. An equal number of corms per class was planted each month.

The first monthly planting for the 1935-1936 season was made on July 2, 1935; the second, on August 1, 1935; the third, on September 3, 1935; the fourth, on October 1, 1935; the fifth, on November 4, 1935; the sixth, on December 2, 1935; and the seventh, on January 10, 1936. As the seventh planting showed a very poor percentage of germination, it was discontinued.

The first planting of the 1936-1937 season was made on July 6, 1936; the second, on August 4, 1936; the third, on September 5, 1936; the fourth, on October 3, 1936; the fifth, on November 3, 1936; the sixth, on December 5, 1936; and the seventh, on January 4, 1937. As the seventh planting in this season also showed a very poor percentage of germination, it, too, was discontinued.

Care of the culture

The plants were weeded with a garden hoe and trowel. At the same time, they were cultivated lightly.

Harvesting

About three months after blooming, when two-thirds of the upper leaves had turned yellow, the corms were harvested. This usually occurs about six months after planting.

RESULTS

The results of the experiments are shown in tables 1 to 3 inclusive. Table 1 shows the number of days from planting to harvesting as affected by storing the corms for the 1935-1936 and the 1936-1937 seasons.

Table 2 shows the germination and flower production as affected by storing for the 1935-1936 and 1936-1937 seasons.

Table 3a shows the production of corms and cormlets for the 1935-1936 season as affected by the class and length of time for storing corms before planting, and table 3b, for the 1936-1937 season.

DISCUSSION OF RESULTS

Maturity of plants

1935-1936 season. Table 1 shows that the number of days required for the plants to mature varied. They matured 191, 185, 175, 160, 148, 140, and 122 days for the first, second, third, fourth, fifth, sixth, and seventh plantings, respectively. The number decreased from the first to the seventh planting; the seventh planting matured 69 days earlier than the first.

1936-1937 season. The results in this season confirmed those of the preceding. For the 1936-1937 season the corms lasted until the seventh planting. The number of days required by the different plantings to mature were 187, 184, 171, 154, 141, 110, and 111 for the first, second, third, fourth, fifth, sixth, and seventh plantings, respectively. In this season the seventh planting matured 76 days earlier than the first.

Germination and flower production as affected by the length of time the corms were in storage

1935-1936 season. Table 2 shows that the percentage of germination in the first planting was 100. For the rest of the plantings, the percentages were: 99.51, 98.53, 95.12, 84.87, 21.46, and 4.38.

As to flowering, the first, second, third, fourth, fifth, sixth, and seventh plantings gave 98.03, 94.11, 84.15, 64.61, 32.18, 6.81, and 0 per cent, respectively.

In the number of days to flower, the same table shows that the first, second, third, fourth, fifth, and sixth plantings gave 83.33 $\pm$ 0.88, 80.73 $\pm$ 0.76, 73.79 $\pm$ 1.40, 72.82 $\pm$ 2.25, 70.49 $\pm$ 0.89, and 69.00 $\pm$ 2.28, respectively.

In the number of buds per spike, the first, second, third, fourth fifth, and sixth plantings gave 9.06 ± 0.067, 7.34 ± 0.101, 6.19 ± 0.296, 6.09 ± 0.118, 5.71 ± 0.102, and 5.26 average, respectively.

1936-1937 season. In the same table, the results for the 1936-1937 season with few exceptions are similar to those obtained in the 1935-1936 season.

Production of corms and cormlets as affected by size of parent corm and time of planting

1935-1936 season. Table 3a shows that the larger the corms planted the greater the number of corms produced.

1936-1937 season. For the 1936-1937 season, practically the same results as in the 1935-1936 season were observed.

SUMMARY

1. Large-sized corms produced a greater number of buds per spike, longer stems, and a greater number of corms and cormlets than smaller ones.

2. In the seven monthly plantings, the first, immediately after the corms had germinated, was the best stage for planting gladiolus.

3. Gladiolus corms could only be kept in storage for seven months after they had shown signs of germination.

4. For successful flower production, gladiolus corms should be planted within three months after they have germinated in storage.

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TABLE 1

Number of days from planting to harvesting of gladiolus corms as affected by time of planting

PLANTINGS	1935-1936 SEASON		1936-1937 SEASON	
	Date planted	Duration of culture	Date planted	Duration of culture
		days		*days*
First	July 2, 1935	191	July 6, 1936	187
Second	August 1, 1935	185	August 4, 1936	184
Third	September 3, 1935	175	September 5, 1936	171
Fourth	October 1, 1935	160	October 3, 1936	154
Fifth	November 4, 1935	148	November 3, 1936	141
Sixth	December 2, 1935	140	December 5, 1936	110
Seventh	January 10, 1936	122	January 4, 1937	111

TABLE 2

Germination and flowering as affected by the length of storage
(1935–1936 Season)

DATE OF PLANTING	NUMBER PLANTED	GERMINATION		FLOWERING			
		Number of corms	Percentage	Number flowered	Percentage	Days to flower	Number of buds per spike
First planting, July 2, 1935	255	255	100.00	250	98.03	83.33 ± 0.88	9.06 ± 0.067
Second planting, August 1, 1935	205	204	99.51	192	94.11	80.73 ± 0.76	7.34 ± 0.101
Third planting, September 3, 1935	205	202	98.53	170	84.15	73.79 ± 1.40	6.19 ± 0.296
Fourth planting, October 1, 1935	205	195	95.12	126	64.61	72.82 ± 2.25	6.09 ± 0.118
Fifth planting, November 4, 1935	205	174	84.87	56	32.18	70.49 ± 0.89	5.71 ± 0.102
Sixth planting, December 2, 1935	205	44	21.46	3	6.81	69.00 ± 2.28	5.26 average
Seventh planting, January 10, 1936	205	9	4.38	0	0		
(1936–1937 Season)							
First planting, July 6, 1936	159	158	98.74	149	94.30	83.33 ± 0.49	9.72 ± 0.174
Second planting, August 4, 1936	159	154	96.22	127	82.96	81.25 ± 0.49	8.62 ± 0.133
Third planting, September 5, 1936	159	143	89.87	111	77.62	76.26 ± 0.66	6.87 ± 0.110
Fourth planting, October 3, 1936	159	133	83.64	80	60.15	72.44 ± 0.96	6.24 ± 0.205
Fifth planting, November 3, 1936	159	120	75.47	33	27.50	66.49 ± 0.85	6.18 ± 0.232
Sixth planting, December 5, 1936	159	95	59.74	6	6.31	60.91 ± 0.41	6.03 ± 0.123
Seventh planting, January 4, 1937	159	11	6.91	0	0		

TABLE 3a

Production of corms and cormlets as affected by the class of corms and the time of planting
(1935-1936 Season)

TIME OF PLANTING	CLASS	NUMBER PLANTED	CORMS			CORMLETS		STEM LENGTH (AVERAGE)
			Total produced	First class corms produced	Percentage of increase	Total produced	Average per plant	
				per cent				*cm.*
First planting, July 2, 1935	First	50	120	76.66	140.00	403	8.06	99.7
	Second	50	108	76.85	116.00	345	6.90	99.4
	Third	100	194	68.55	94.00	619	6.19	93.2
	Fourth	40	54	66.66	35.00	199	4.98	89.9
	Fifth	15	19	47.36	26.67	65	3.67	87.7
Second planting, August 1, 1935	Second	50	105	61.90	110.00	240	4.89	99.8
	Third	100	174	45.40	74.00	327	3.27	93.2
	Fourth	40	49	55.10	22.50	88	2.20	84.9
	Fifth	15	17	17.64	13.33	28	1.87	78.2
Third planting, September 3, 1935	Second	50	111	34.23	122.00	230	4.60	74.4
	Third	100	187	22.99	87.00	474	4.74	72.1
	Fourth	40	48	39.58	20.00	149	3.92	69.4
	Fifth	15	15	40.00	0	63	4.50	71.5

TABLE 3a continued

TIME OF PLANTING	CLASS	NUMBER PLANTED	CORMS			CORMLETS		STEM LENGTH (AVERAGE)
			Total produced	First class corms produced	Percentage of increase	Total produced	Average per plant	
				per cent				*cm.*
Fourth planting, October 1, 1935	Second	50	109	9.17	118.00	186	3.88	73.2
	Third	100	196	14.28	96.00	398	4.15	71.4
	Fourth	40	49	4.08	22.50	106	2.79	70.1
	Fifth	15	15	0	0	40	2.67	71.1
Fifth planting, November 4, 1935	Second	50	93	0	86.00	194	4.22	72.8
	Third	100	162	2.46	62.00	184	2.16	69.6
	Fourth	40	43	0	7.50	63	2.03	69.6
	Fifth	15	16	0	6.67	14	1.17	70.0
Sixth planting, December 2, 1935	Second	50	32	0	—36.00	39	1.23	71.8
	Third	100	19	0	—81.00	21	1.62	63.8
	Fourth	40	0	0	—100.00	0	0	
	Fifth	15	0	0	—100.00	0	0	
Seventh planting, January 10, 1936	Second	50	8	0	—84.00	2	0.40	
	Third	100	5	0	—95.00	0	0	
	Fourth	40	0	0	—100.00	0	0	
	Fifth	15	0	0	—100.00	0	0	

TABLE 3b

Production of corms and cormlets as affected by the class of corms and the time of planting (1936–1937 Season)

TIME OF PLANTING	CLASS	NUMBER PLANTED	CORMS			CORMLETS		STEM LENGTH (AVERAGE)
			Total produced	First class corms produced	Percentage of increase	Total produced	Average per plant	
				per cent				*cm.*
First planting, July 6, 1936	First	120	387	50.39	222.50	811	6.76	100.71
	Second	20	60	41.66	200.00	134	6.70	98.52
	Third	8	19	36.84	137.00	41	5.15	95.81
	Fourth	7	7	57.14	0	14	2.00	92.43
	Fifth	4	3	0	—25.00	5	1.67	89.17
Second planting, August 4, 1936	First	120	420	39.42	250.00	599	5.03	97.19
	Second	20	61	36.06	205.00	69	3.45	96.87
	Third	8	14	21.43	75.00	26	4.33	93.33
	Fourth	7	7	57.14	0	19	3.17	84.70
	Fifth	4	3	0	—25.00	4	1.33	80.33
Third planting, September 5, 1936	First	120	375	4.28	212.50	351	3.13	83.60
	Second	20	49	16.22	145.00	66	3.67	75.86
	Third	8	14	14.29	75.00	10	1.67	70.33
	Fourth	7	9	0	28.57	10	2.50	70.75
	Fifth	4	3	33.33	—25.00	7	2.33	62.67
Fourth planting, October 3, 1936	First	120	310	3.55	158.33	268	2.50	75.79
	Second	20	41	7.31	105.00	35	2.33	74.83
	Third	8	9	0	12.50	7	1.40	70.50
	Fourth	7	5	0	—28.57	2	0.50	68.50
	Fifth	4	2	0	—50.00	0	0	70.25

TABLE 3b (continued)

TIME OF PLANTING	CLASS	NUMBER PLANTED	CORMS			CORMLETS		STEM LENGTH (AVERAGE)
			Total produced	First class corms produced	Percentage of increase	Total produced	Average per plant	
Fifth planting, November 3, 1936	First	120	276	2.17	130.00	143	1.44	74.94
	Second	20	33	0	65.00	10	0.77	71.08
	Third	8	6	0	—25.00	1	0.25	67.25
	Fourth	7	3	0	—57.14	2	0.67	66.50
	Fifth	4	1	0	—75.00	0	0	
Sixth planting, December 5, 1936	First	120	229	1.74	90.83	100	1.15	73.69
	Second	20	4	0	—80.00	4	1.00	
	Third	8	4	0	—50.00	5	1.67	
	Fourth	7	1	0	—85.71	0	0	
	Fifth	4	0	0	—100.00	0	0	
Seventh planting, January 4, 1937	First	120	21	0	—82.50	1	0.91	
	Second	20	0	0	—100.00	0	0	
	Third	8	0	0	—100.00	0	0	
	Fourth	7	0	0	—100.00	0	0	
	Fifth	4	0	0	—100.00	0	0	

MANUFACTURE OF SOFT CHEESE[1]

SISENANDO R. REANTASO

Soft cheese is a popular product in many parts of the Philippines. Owing to its high nutritive value, its manufacture should be encouraged throughout the country.

Milk for cheese manufacture may be obtained from various classes of farm animals, as the Philippine carabao, the Indian buffalo, different breeds of cattle, and the goat. Therefore, it is important to know the relative value of milk from such animals, not only as to cheese yield but also as to the food value of the products derived. Besides, the quality of the local product should be improved, if possible, so that a uniform and sanitary product may be produced.

Review of literature

Michels (1903-1904) reported that milk testing 3 per cent fat gave 8.24 pounds (3.74 kilograms) of cheese per one hundred pounds (45.45 kilograms) of milk; 3.5 per cent fat, 9.53 pounds (4.33 kilograms); 4 per cent fat, 10.35 (4.7 kilograms); 4.5 per cent fat, 11.41 pounds (5.18 kilograms); and 5 per cent fat, 12.74 pounds (5.8 kilograms).

Dean (1909) found that a slight increase in the percentage of casein had quite a marked effect on the yield of cheese, and that the increase in casein content of the milk is always accompanied by an increase in fat. An average increase of 0.15 per cent casein and 0.17 per cent fat in the milk gave an average increase of 3.58 pounds (1.62 kilograms) of cheese per 1,000 pounds (454.5 kilograms) of milk. The fact that the cheese yield of milk corresponds to its fat content was further confirmed by the work of Gere (1922) and Alvord (1896).

According to Limuaco (1925), every liter of milk when made into Santa Cruz cheese (using Hansen's Danish rennet extract) produced from 212 to 450 grams of cheese, or an average of 338 grams; when made into Cebu cheese, it produced from 238.7 to 298 grams, or an average of 257.48 grams; and when made into Meycauayan cheese, it produced from 556 to 584 grams, or an average of 572 grams.

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[1] Experiment Station contribution No. 1386. Prepared in the Department of Animal Husbandry under the direction of Assistant Professor F. B. Sarao.

The average chemical composition of the Santa Cruz cheese was found by the same author to be as follows: moisture, 54.24 per cent; casein, 12.78 per cent; butter fat, 26.15 per cent; reducing sugar, 1.95 per cent; ash, 4.35 per cent; sodium chloride, 2.42 per cent; and acidity, 13.08 ml. 0.1N NaOH per 100 grams sample. That of the Cebu cheese was: moisture, 47.35 per cent; casein, 18.76 per cent; butterfat, 28.35 per cent; reducing sugar, 1.62 per cent; ash, 3.42 per cent; sodium chloride, 1.66 per cent; and acidity, 33.32 ml. 0.1N NaOH per 100 grams of sample. That of the Meycauayan cheese was: moisture, 66.31 per cent; casein, 9.54 per cent; butterfat, 18.70 per cent; reducing sugar, 1.70 per cent; ash, 3.45 per cent; sodium chloride, 2.41 per cent; and acidity, 40.09 cubic centimeters per 100 grams of sample.

According to Arbuckle (1939), if the fat percentage in cheese is low, the cheese may be dry and without mellowness; if too high, it may be oily. Fat also gives mellowness, smoothness, and richness of taste—all contributing to make the cheese palatable. The same author further states that casein, like fat, influences in some degree the quality of the cheese, so that an excess causes the body to be hard and dry.

The present work had for its objects the following: (*a*) to determine the quantity and quality of cheese made from milk of different classes of farm animals, and (*b*) to find an improved method that will produce efficiently a uniform and sanitary product.

The experiment was conducted in the Department of Animal Husbandry from June, 1926, to February, 1928, a period of about one year and eight months. During this period the writer made trips to Santa Cruz, Laguna, and to Meycauayan, Bulacan, to observe the native methods of making cheese.

Milk used

The milk used in this experiment was obtained from Philippine carabaos, Indian buffaloes, and Nellore and Native cows.

Curdling materials and preparation of the rennet extract, 10 per cent solution

Two curdling materials were used, namely, Hansen's Danish rennet extract and native vinegar. Rennet extract was used in making the Improved Santa Cruz and Cebu cheese; and vinegar, in making the Meycauayan cheese.

The ten per cent solution of Hansen's Danish rennet extract was prepared by mixing one cubic centimeter of the pure rennet extract with nine cubic centimeters of clean water. Cheese makers who use Hansen's Danish rennet extract are cautioned to prepare only as much of the 10 per cent solution as will be needed for each setting of the milk, because once water is added, the solution spoils within two days. Furthermore, neither the solution nor the pure rennet extract should be exposed to light or to warm temperature when put aside for future use because the curdling power of the rennin is weakened when so exposed.

Equipment

The equipment was:

(a) Pails and pitchers for setting the milk.
(b) Cheesecloth for straining the milk, separating the whey from the curd, and covering the cheese while hardening in the mold.
(c) Bamboo knife for cutting the curd and dividing the cheese slabs.
(d) Wooden paddle for working the curd, and for putting the cheese slab into a wrapper.
(e) Balance.
(f) Wooden molds 20 × 10 × 4 centimeters for the Improved Santa Cruz and Meycauayan cheese.
(g) Cheese press.

Methods of manufacture

Santa Cruz method. The following description of the procedure used in making Santa Cruz cheese was based on actual observations at ten different places in Santa Cruz.

Besides the milk, homemade rennet extract, and salt, the equipment and materials commonly used in making the Santa Cruz cheese were: a kerosene can, a perforated basin, banana leaves, pails, and tying materials. The utensils were washed with water without soap and were not sterilized. Milk from different sources was brought early in the morning in open kerosene cans. To prevent the milk from spilling, pieces of banana leaves were placed on the surface. The cheese maker started her work by straining the milk through a piece of *sinamay* (abacá) cloth into pails or another kerosene can. More than forty grams of sediment was collected from each kerosene can of milk strained. After the milk was strained, the rennet extract was poured into it and stirred sufficiently to distribute the rennin uniformly. As soon as complete curdling had taken place, which generally took from one and a half to two hours, the curd was put into a perforated basin to drain off the whey. Then the

curd was put into a pail, where it was crumbled by the hand and salted to taste. The salted curd was placed in circular molds of banana stalk, which were set over pieces of banana leaf on a table. The banana stalk mold had a height of four centimeters and a diameter of from eight to ten centimeters. This mold was placed inside a larger, square wooden mold, which acted as a support. The cheese was left uncovered to harden. Then the cheese cakes including the banana leaf molds were wrapped with wilted banana leaves. This was done two or three hours after the cheese cakes had been in the mold. Such cheese was usually not sold until the following day. According to Limuaco (1925), cheese made in the morning will be hard enough to be used the next day.

While the writer was observing the procedure used in making the Santa Cruz cheese, he noted the following faults, quite common among makers of this cheese:

1. Milk containers and other utensils were not properly cleaned and sterilized before using.
2. The hands were used much throughout the process in macerating the curd before draining the whey, in mixing the salt, and in wrapping the cheese with banana leaves.
3. There was a lack of uniformity in size of the product.
4. Banana leaf was used instead of cheese cloth or sinamay in draining the whey from the cheese. This not only delayed the hardening of the cheese to the desired texture, generally taking from six to eight hours, but it also permitted the whey to run over the floor.

The Improved Santa Cruz method. The first step in the manufacture of the Improved Santa Cruz cheese was to wash thoroughly and sterilize all the utensils and washable materials immediately before using. The milk was strained and set in aluminum pails or pitchers within one hour after milking.

To coagulate every liter of milk of the Philippine carabao or Indian buffalo, about three milliliters of the 10 per cent solution of the Danish rennet extract was required, whereas only about two milliliters of this solution was needed to coagulate one liter of milk of the Native or Nellore cow. The difference in amount of the rennet extract required for coagulating the milk from different classes of animals depends on the amount of the total solids present in the milk (table 1). The milk of the Philippine carabao or Indian buffalo contains about nineteen to twenty-two per cent total solids while that of the Native or Nellore cow contains only about thirteen to fourteen per cent. In all cases, before being added to the milk,

the ten per cent solution was diluted with pure water to eight or nine times the original volume. The purpose of doing this was to facilitate uniform distribution of rennin, which is essential in cheese making. To insure further thorough mixing, the milk was stirred a few seconds before the rennin was gradually poured into it. This stirring was kept up for one or two minutes after all the coagulant had been added.

The milk was then left until the coagulation was complete—generally from one and a half to two hours. Complete coagulation was shown by the appearance of the supernatant clear liquid or whey on the surface of the coagulum.

The curdled milk was cut into small pieces with a bamboo knife to free the whey. Then the whey was separated by straining the curd through cheesecloth. Enough whey was left with the curd to make it neither too dry nor too wet before it was placed in the wooden mold. After the whey was separated, the curd was put into a pitcher and weighed. Here it was salted. The amount of salt used was based on the weight of the curd obtained. This was verified by occasional tasting while the salt was being thoroughly mixed with the curd with a wooden paddle. The salted curd was then put in the wooden molds where it remained for two or three hours to harden a little so the cake would hold its form. Then the cheese was wrapped with clean onion skin paper and again with boiled banana leaf before it was sold.

By this procedure, the use of the hand in the making of cheese was eliminated from beginning to end.

Cebu method. From setting to salting, practically all the operations used in making the Improved Santa Cruz cheese were followed in the making of the Cebu cheese. This method differed from the original method used in Cebu in that the commercial rennet extract was used instead of that made with a piece of dry abomasum soaked in vinegar. In salting the Cebu cheese, about thirty-six grams of salt per kilogram of curd was required; this was about eight grams more than was required for the Improved Santa Cruz cheese. This extra amount was used to give allowance for the amount lost while the cheese was in the press. Before the salted curd was put into the wooden mold, it was wrapped with cheesecloth to prevent the squeezing out of the curd from the mold when pressure was applied. At the very start only a little pressure should be applied lest the curd next to the cheesecloth form a paste and thus prevent the flow of the whey. After twenty-four to thirty-six hours, the pressure was

removed and the cheese slabs were taken from the molds. The finished cheese was wrapped in the same way as the Improved Santa Cruz cheese.

Meycauayan method. The fresh milk, after being strained, was put in a pitcher and heated in a double boiler to about 140°F. (60°C.) Although the thermometer was used in this study, one can determine approximately the right temperature of the milk by dipping his forefingers into it three times at one second intervals. If on the third dipping he can no longer withstand the heat, the milk is estimated to be at a temperature of 140°F. (60°C.) Instead of pouring the heated milk into the pail containing the vinegar as was done in Meycauayan, warm vinegar was poured slowly into the heated milk. This was done in order to facilitate the uniform distribution of the vinegar and to control the amount needed. The milk was stirred while the vinegar was gradually added until the milk curdled. Less than two hundred milliliters of local vinegar of two to three per cent acetic acid was sufficient for every two liters of milk if warmed, and a little more than two hundred milliliters if cold. In case the whey was still cloudy, more vinegar was added to insure complete coagulation. The coagulation, or curdling, took place almost immediately. The usual practice in Meycauayan was to use the hand to squeeze out the whey from the curd; in this work the curd was drained through cheesecloth. The separation of the whey was very rapid because the curd formed a solid mass. The curd was put back in the pitcher where it was crumbled with a small wooden paddle and salted to taste. In Meycauayan the salting was done quite differently because the cheese was soaked in a brine solution after it had been pressed in the bamboo tube. The College method of salting is preferable because the salt is better mixed with the curd, and the cheese can be served either immediately after, or allowed to stand two to three hours in the same wooden molds used for the Improved Santa Cruz cheese. The Meycauayan cheese was wrapped in the same manner as the Improved Santa Cruz cheese.

Plan of the experiment

In determining the cheese production of the four different kinds of milk used in these experiments by the three methods, two liters of each kind of milk were used at each trial. Preliminary trials were first undertaken to familiarize the writer with the different methods of manufacture, thus enabling him to produce as uniform a product as possible from the same kind of milk. In the morning

following the day of making, one half slab of each kind of cheese made was submitted for analysis. The other half was kept in the ice box for the determination of the keeping quality.

Improved Santa Cruz cheese. Eleven determinations on each kind of milk were performed, except on the Nellore cow milk, where there were ten. After the whey was separated, the curd was put into a pitcher and weighed. Here it was salted to taste and thoroughly worked with a wooden paddle. The amount of salt added to the curd in each experiment was recorded in order to determine the optimum amount for every kilogram of curd. After being salted, the curd was put into a wooden rectangular mold where it was allowed to stay for two to three hours. The cheese was weighed immediately after it was removed from the mold and then wrapped with the onion skin paper.

Cebu cheese. Ten determinations of each kind of milk were conducted. The method of obtaining the weight of the curd and the amount of salt added was the same as that followed in making the Improved Santa Cruz cheese. The cheese was allowed to stay in the mold for a period ranging from twenty-four to thirty-six hours. The weight of the cheese was taken immediately after it had been removed from the mold.

Meycauayan cheese. Four determinations of each kind of milk were conducted following the Meycauayan method as modified in this study.

RESULTS AND DISCUSSION

Cheese yield per liter of milk from four different kinds of animals compared

Table 2 shows the average cheese yields per liter of different kinds of milk when made into the three kinds of cheese under study.

Improved Santa Cruz cheese. The cheese yield per liter of the Nellore milk ranged from 109.1 to 192.2 grams, or an average of 156.11; that of the Native cow milk, 146.7 to 236.2, or an average of 185.51 grams; that of the Indian buffalo milk, 213.2 to 297.9, or an average of 254.06 grams; and that of the Philippine carabao milk, from 249.2 to 377.1 grams, or an average of 324.63.

Cebu cheese. When made into Cebu cheese, the different kinds of milk used had the following yields: that of the Nellore cow, 82.5 to 121.7 grams, or an average of 99.07 grams; Native cow, 96.5 to 131.7, or an average of 115.95 grams; Indian buffalo, 85.5 to

232.7, or an average of 158.17 grams; and that of the Philippine carabao, 143.5 to 228.3, or an average of 188.49 grams of cheese.

Meycauayan cheese. The yields per liter of the various kinds of milk studied when made into Meycauayan cheese were as follows: that of the Nellore cow, from 167.7 to 182.3 grams, or an average of 177.16 grams; Native cow, 187.6 to 207.0 grams, or an average of 193.97 grams; Indian buffalo, 210.2 to 232.1 grams, or an average of 218.76 grams; and Philippine carabao, 240.0 to 381.2 grams, or an average of 311.93 grams.

The figures in table 2 show that the production per liter of the Philippine carabao milk, whether it was made into Improved Santa Cruz, Cebu, or Meycauayan cheese, was always about two times as much as that of the Nellore cow milk; about 1.6 times as much as that of the Native cow; and about 1.3 times as much as that of the Indian buffalo. These results bring us face to face with the question: why is it that the cheese yield per liter of one kind of milk differs from that of another?

According to Van Slyke and Publow (1914), the constituents of the milk that furnish the solid materials for cheese are mainly butterfat and casein. For this reason the yield of cheese from any milk depends almost wholly on the amount of butterfat and casein present in the milk.

Philippine carabao milk, which gave the highest cheese yield, contains the greatest amount of butterfat and casein (table 1). Nellore cow's milk, on the other hand, which contains the least amount of butterfat and is next to the lowest in the amount of casein had the lowest cheese yield. In butterfat and casein content, Native cow and Indian buffalo milk retain the same rank that they hold in the cheese yield.

Chemical composition of soft cheeses made by three methods from different kinds of milk

Table 3 shows the average chemical composition of soft cheese made from four different kinds of milk by the three different methods studied.

Moisture. The moisture content of soft cheese made from four different kinds of milk under the same method had very slight variation (table 3). Evidently, it was the method of manufacture that caused the great variation. For example, when the carabao milk was made into Improved Santa Cruz cheese, it had an average moisture content of 54.98 per cent. But when the same kind of milk was

made into Cebu cheese, the product had only an average of 43.33 per cent of moisture, or a difference of 11.65 per cent in favor of the Improved Santa Cruz cheese. Such a difference was due to the pressure to which only the Cebu cheese was subjected. The moisture content of the cheese has no relation to the water content of the milk from which it was made (tables 1 and 3).

Butterfat and casein. In all three kinds of cheese, the higher the butterfat content of the milk, the higher was the content of the same nutrient in the cheese made from it in proportion to other constituents (tables 1 and 3). It may also be noted that the casein content of the cheese decreased as the butterfat content increased, except in the case of the Meycauayan cheese and the Philippine carabao milk made into Cebu cheese. As a whole, however, the results agree with those of Van Slyke and Publow (1914). Such a decrease in the casein content of the cheese may be expected when the butterfat content increases because the ratio between the butterfat and casein contents in the milk becomes wider as the amount of butterfat increases. In other words, while the casein content of the milk increases with the increase of butterfat, its rate of increase is less than that of the butterfat.

Sodium chloride. The Improved Santa Cruz and the Meycauayan cheese required about the same amount of salt, or an average of about 28 grams for every kilogram of curd, or 2.8 per cent (table 2). The Cebu cheese required an average of about 36 grams for every kilogram of curd, or 3.6 per cent. This is 0.8 per cent more than the amount required for either the Improved Santa Cruz or the Meycauayan cheese.

In the finished products, the salt content of the cheese did not vary much with the different kinds of milk made into the same kind of cheese, nor with the same kind of milk made into three different kinds of cheese (table 3). The average salt content of the Improved Santa Cruz cheese was 1.98 per cent; that of Cebu cheese, 1.81 per cent; and that of the Meycauayan cheese, 1.75 per cent. When the amount of salt added to the curd and the amount of salt found in the finished products are compared, it will be found that, between the time when the curd was salted and the time the analysis was made, there was lost in the Improved Santa Cruz cheese about 29 per cent of its original amount; in the Cebu cheese, about 50 per cent; and in the Meycauayan cheese, about 38 per cent.

Composition of cheese in relation to quality

The amount of butterfat contained in the cheese appears to be the factor determining its quality. Arbuckle (1939) points out that fat contributes towards the mellowness and palatability of the cheese. The proportion of butterfat to casein is very much larger in the Philippine carabao cheese than in the Nellore cow cheese (table 3). While the Philippine carabao cheese was smooth, mellow, and very palatable, that of the Nellore cow was coarse and hard in texture and less palatable. Arbuckle (1939) mentioned the effect of the casein on cheese which in large amounts imparts hardness and dryness to the product. The Nellore cheese has high percentage of casein in all methods except in the Meycauayan (table 3). Alvord (1896), on the relation of butterfat content to the quality of cheese, says "Other things being equal, a cheese containing a large proportion of fat is better, because, first, of its finer flavor and taste; second, of its better consistency; third, of its improved aroma; fourth, of its increased digestibility; fifth, of its more perfectly answering the requirements of a complete food or balanced ration."

Judging the quality of our soft cheese on the basis of butterfat content, we can list them in the following order: Philippine carabao cheese, first; Indian buffalo cheese, second; Native cow cheese, third; and Nellore cow cheese, fourth.

As regards the keeping quality, it can be safely stated that, with the exception of the Cebu cheese, they are best when fresh. The Cebu cheese tasted best after about one week of curing. Under room temperature, the Cebu cheese kept as long as one month and the Improved Santa Cruz and the Meycauayan cheese for four days.

SUMMARY AND CONCLUSIONS

1. The production per liter of the Philippine carabao milk when made according to any of the three methods was always twice as much as that of the Nellore cow milk, about 1.6 times as much as that of the Native cow milk, and about 1.3 times as much as that of the Indian buffalo milk.

2. The yield of cheese from any milk depends upon the amount of butterfat and casein that it contains; the higher the percentage of butterfat and casein in a milk, the greater is the cheese yield per liter of that milk.

3. The higher the butterfat content of the milk from which the cheese is made, the higher is the butterfat content of the cheese in proportion to other constituents.

4. The moisture content of soft cheese made from different kinds of milk under the same method had very slight variations. It is the method employed that affects the moisture content of the cheese rather than the kind of milk used.

5. For every kilogram of curd, the Improved Santa Cruz and the Meycauayan cheese required 28 grams of salt. The Cebu cheese required 36 grams, or 8 grams more than that required in the Improved Santa Cruz and Meycauayan cheese. In the finished products, the three kinds of cheese had about the same amount of salt. Between the time the curd was salted and the time the cheese was ready for the table, the Improved Santa Cruz cheese lost about 29 per cent of its original salt; the Cebu cheese, about 50 per cent; and the Meycauayan, about 38 per cent.

6. If the quality of Philippine soft cheese is judged on the basis of butterfat content, it can be listed in the following order: Philippine carabao cheese, first; Indian buffalo, second; Native cow, third; and Nellore cow, fourth.

7. Of the three kinds of cheese made, the Cebu cheese had the best keeping quality; the Improved Santa Cruz and the Meycauayan cheese had the poorest. The last two kinds when kept under room temperature were fit for food for four days and the Cebu cheese for one month.

8. A wholesome sanitary cheese can be produced by (*a*) using only clean milk, (*b*) sterilizing all the utensils needed in processing immediately before using, and (*c*) by using spoons, bamboo knife, and wooden paddle instead of fingers for breaking and salting the curd.

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TABLE 1

Average composition of the different kinds of milk used

KIND OF MILK	SPECIFIC GRAVITY	MOISTURE	TOTAL SOLIDS	LACTOSE	FAT	PROTEIN	CASEIN	ALBUMIN	ASH
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Nellore cow [a]	1.025	86.50	13.49	4.65	3.75	3.07	2.75	0.64	0.87
Native cow [a]	1.029	85.01	14.99	4.53	4.33	3.29	2.70	0.59	1.10
Indian buffalo [b]	1.031	80.99	19.01	4.89	7.31	5.74	4.48	1.26	0.81
Philippine carabao [b] .	1.035	77.66	22.34	4.93	10.17	5.98	4.73	1.25	0.87

[a] Analyses by the Department of Agricultural Chemistry.

[b] GOMEZ, JOSÉ S. 1926. Comparative analysis of the milk of carabao and Indian buffalo. The Philippine Agriculturist 15: 75–84.

TABLE 2

Average cheese yields per liter of four different kinds of milk, made by each of the three methods studied.

KIND OF MILK USED	NUMBER OF SAMPLES	WEIGHT OF SALT REQUIRED FOR EVERY KILOGRAM OF CURD	CHEESE YIELD PER LITER OF MILK
		grams	*grams*
Improved Santa Cruz method			
Nellore cow	10	28.34	156.11
Native cow	11	28.26	185.51
Indian buffalo	11	26.65	254.06
Philippine carabao	11	26.54	324.63
Cebu method			
Nellore cow	10	37.99	99.07
Native cow	10	38.55	115.95
Indian buffalo	10	33.98	158.17
Philippine carabao	10	34.81	188.49
Meycauayan method			
Nellore cow	4	30.70	177.16
Native cow	4	32.85	193.97
Indian buffalo	4	28.13	218.76
Philippine carabao	4	23.28	311.93

TABLE 3

Average chemical composition of soft cheese made from four different kinds of milk by the three methods (Analysis by the Department of Agricultural Chemistry)

Improved Santa Cruz cheese

KIND OF MILK	MOISTURE	ASH	BUTTER FAT	REDUCING SUGAR	CASEIN BY DIFFERENCE	SODIUM CHLORIDE	ACIDITY EXPRESSED IN CC. 0.1N NaOH PER 100 GRAM SAMPLE
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*cc.*
Nellore cow	54.30	4.31	17.85	1.94	20.39	1.95	9.20
Native cow	55.03	4.07	17.88	1.92	18.39	1.88	9.25
Indian buffalo	58.80	4.24	19.29	2.07	15.60	2.09	10.72
Philippine carabao	54.98	4.25	22.87	2.25	15.62	2.02	6.41
Cebu cheese							
Nellore cow	44.50	4.73	21.90	0.52	27.31	1.79	18.18
Native cow	44.48	4.67	26.30	0.59	24.34	1.81	17.11
Indian buffalo	43.56	4.99	27.79	0.70	23.10	1.86	23.03
Philippine carabao	43.33	4.65	28.07	0.69	23.23	1.79	19.73
Meycauayan cheese							
Nellore cow	64.13	2.03	14.35	1.49	15.02	1.85	53.55
Native cow	61.09	4.41	16.65	1.66	16.19	1.49	41.89
Indian buffalo	54.69	4.18	18.99	1.43	25.71	1.91	24.69
Philippine carabao	46.05	4.02	26.98	1.35	21.59	1.77	27.97

TRIAL CULTURE OF CITRONELLA GRASS [1]

PEDRO A. DAVID
Of the Department of Agronomy

WITH THREE TEXT FIGURES

Citronella grass, *Cymbopogon nardus* Rendle, extensively grown in Ceylon and Java for the extraction of citronella oil, is one of the new crops under study by the Department of Agronomy because of its possibilities for commercial culture in this country. This paper reports the results of a trial culture of citronella grass on a small scale at the College of Agriculture and on a commercial scale at the Calamba Sugar Estate at Canlubang, Laguna.

According to Macmillan [2] (1935), two distinct varieties of *Cymbopogon nardus,* Maha-pangiri and Heen-or Lenabatu-pangiri, are found in Ceylon. The former, also known as Winter's grass, bears long, broad leaves; it is rich in oil, but requires frequent replanting. Heen- or Lenabatu-pangiri is considered hardier and is often preferred for planting. A robust variety known as "Java Maha-pangiri" at Peradeniya was introduced from Java. This variety is characterized by its long, broad, drooping leaves.

Citronella oil, which is extracted from the leaves of the grass, is mainly used in the perfumery and soap-making industries. Evidently not particular in its soil requirements, citronella grass is often planted on slopy land to prevent soil erosion.

Objects of the present work

The objects of this study were: (*a*) to study the methods of planting citronella grass on a commercial scale, (*b*) to determine the cost of planting one hectare, and (*c*) to study the relation of age of the grass at cutting to the yield of oil.

Time and place of the present work

The work herein reported was started on August 7, 1936, and concluded on July 26, 1939. The commercial field plantings and ex-

[1] Experiment Station contribution No. 1387. Prepared in collaboration with the Calamba Sugar Estate, Canlubang, Laguna, to whom the writer is indebted.

[2] MACMILLAN, H. F. 1935. Tropical planting and gardening with special reference to Ceylon. x + 560 p., 472 fig. London: Macmillan and Co., Ltd.

traction and analyses of oil were conducted in the Calamba Sugar Estate under Mr. H. J. Rothkirch, resident manager; Mr. H. Halden, chemist; and Mr. R. Ruiz, field superintendent. The writer wishes to express his indebtedness to these gentlemen for their valued assistance in the preparation of the large scale planting. Samples from the trial plantings in the College Experiment Station were analyzed by the Department of Agricultural Chemistry of the College.

MATERIALS AND METHODS

The citronella grass which is similar to "Java Maha-pangiri" in its character of growth was used in this study. It is shown in figure 1 at the age of one year. It was grown at the College Experiment Station from two original culms given by Dr. Jose M. Capinpin to the writer in 1932 and entered in the Agronomy accession book as C. A. 19621. This original stock of the Department of Agronomy was the source of all the commercial plantings of citronella grass at the Calamba Sugar Estate in 1937.

The field observations and recording of all necessary data including weather data were jointly made by the College of Agriculture and Calamba Sugar Estate workers.

Propagation materials and preparation

The culms from one year old plants not cut for distillation were first separated individually by breaking them off the base of the mother plant, a few roots being left on each culm. The tops were cut back to about forty to fifty centimeters. The amount of planting materials that may be obtained from a year old selected plant is shown in figure 2. The bundles include 125 culms or suckers and 101 root divisions.

Preparation of the land

The field was prepared by plowing and harrowing five times before furrowing. Two methods of furrowing preparatory to setting the culms or suckers were tried. In one method the plowshare with mouldboard was used, and in the other only the plowshare was used. The furrows were made one meter apart, following the contour of the land so as to minimize soil erosion and washing away of the plants.

Planting

Two or three culms were planted in each hill. The hills were 60 centimeters apart. The soil covering the base of the culms was well pressed down.

In the Calamba Sugar Estate, the quantity of planting materials obtained from one hectare was sufficient to plant seven hectares of land.

Cultivation

Cultivation of the soil in the trial culture at the College of Agriculture consisted in hoeing between the rows to keep the weeds down as well as to level the ground. The more extensive Calamba Sugar Estate plantings were cultivated first by an animal-drawn cul-

Fig. 1—One year old Citronella grass grown in the Economic Garden of the College of Agriculture. Photograph by the Photographic Division, College of Agriculture.

tivator. After a week or so, a plow was run through the rows to bury the weeds. Hoes were used to cultivate the soil around the plants not accessible to the cultivator or plow.

Application of fertilizer

The plants were fertilized with ammonium sulfate at the rate of 100 kilograms per hectare. The fertilizer was applied to the base of the plants at a radius of about three centimeters and, with a plow, was covered with soil.

Harvesting

The plants were harvested at various periods of growth in order to determine the relation of age to oil content of the leaves four, five, and seven months after planting, and before they produced tassels. At the Calamba Sugar Estate, harvesting consisted in cutting the leaves at about eighteen to twenty centimeters above the ground. This was done mostly by women laborers using small scythes. Dry leaves and other foreign materials such as soil and weeds were re-

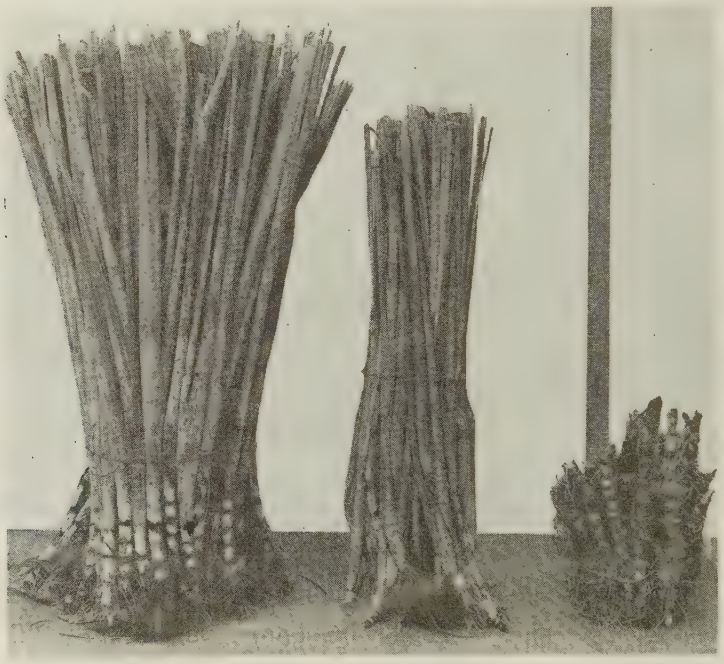

Fig. 2.—Culms, suckers, and root division from a one year old selected Citronella plant. Photograph by the Photographic Division, College of Agriculture.

moved before the cut leaves were tied into bundles of convenient size. After the leaves had been cut off, the stumps were cleared of adhering dry grass so as to allow proper development of the plants of the succeeding crop.

Yield

The weight of the leaves cut at different ages of the plant and the corresponding oil content for the Calamba Sugar Estate culture were recorded (table 4). The extraction and analysis were per-

formed at the chemical laboratory of the Calamba Sugar Estate. The variations in weight of green leaves and number of culms per hill of 161 sixteen month old plants grown at the College of Agriculture were determined (table 2). The percentage of oil extracted from thirteen month old citronella grass at different periods of air drying was determined by the Department of Agricultural Chemistry, College of Agriculture. The analyses are presented in table 3.

RESULTS AND DISCUSSION

Effect of the soil. In the College of Agriculture plantings, good results were obtained from plants grown on well drained, sandy loam

Fig. 3—Six month old Citronella grass planted under old coconut trees in the Calamba Sugar Estate. Photograph by the Photographic Division, College of Agriculture.

soil among rows of bearing cacao trees, pepper, and vanilla plants. Plantings on open, shallow, and poorly drained soil did not give satisfactory results. The commercial plantings at the Calamba Sugar Estate were set on a slightly rolling area of brown, sandy loam soil, with a subsoil of hard adobe. Known to be poor in fertility, the soil was fertilized with ammonium sulfate. The plants grown under coconut trees were vigorous.

Effect of the climate. Citronella grass grows fairly well under the prevalent climatic conditions at the College of Agriculture and the Calamba Sugar Estate at Canlubang, Laguna (table 1).

Effect of cultivation. According to our observations in both the cultures at the College of Agriculture and the Calamba Sugar Estate, thorough cultivation, especially during the summer months, seemed to improve the harvest. Frequent hilling up retarded development of the young shoots.

Rate of propagation. Citronella grass is more readily propagated by culms or suckers than by either root divisions or seeds. For commercial plantings, culms should be planted. The use of seeds should be limited for breeding purposes, for developing superior strains.

An actual count of culms from 161 clumps at the age of one year, four months, and four days showed an average of 63.71 ± 1.71 culms per clump. Estimates made on the Calamba Sugar Estate cultures indicated that at the age of four to seven months, one hectare of citronella grass could produce enough planting materials for seven hectares of land. The average number of culms counted per hill of six month old plants at the Calamba Sugar Estate was about thirty-one. The plants had an average height of 152.4 centimeters. Figure 3 shows the stand of six month old citronella grass grown under bearing coconut trees.

Disease found on the plants of the trial culture. The citronella grass at the Calamba Sugar Estate suffered from a disease caused by what looked to be a species of *Helminthosporium*. The malady was not observed on the College of Agriculture plantings.

Cost of planting per hectare. The actual cost of planting one hectare of citronella grass including the cost of 100 kilos of ammonium sulfate and its application, as reported by the Calamba Sugar Estate, follows:

Plowing (five times)	₱ 25.00
Furrowing	3.00
Preparation of planting materials	2.50
Planting	12.00
Cultivation by animal drawn cultivator	25.00
Weeding by hoeing	20.00
Fertilizer (100 kilos ammonium sulfate)	8.83
Application of fertilizer	1.00
Harvesting	12.57
Total	₱109.90

Observation on harvesting. At the Calamba Sugar Estate, three crops a year could be harvested, without replanting, in April, August, and December. Leaves which were neither too young nor too old

yielded a good quality oil. Grass cut at from three to five months gave better oil than the younger or older leaves. Dry leaves produced oil of very inferior quality. Harvesting should be done before tasseling, which occurs in the months of November and December, and before dry leaves appear in the stools. The lower portion of the stalks contain practically no oil; therefore, it is not necessary to cut the plants close to the ground. Leaves which had fermented or had a considerable admixture of dried leaves, weeds, and other foreign matter were found to yield a poor quality oil.

Yield of grass and oil

The computed mean weight of green leaves per plant at the age of one year, four months, and four days was 3.21 ± 0.12 kilograms with a standard deviation of 2.21 ± 0.08 kilograms and a coefficient of variability of 68.84 ± 2.58 per cent. The mean number of culms per plant at the same age was found to be 63.71 ± 1.71 with a standard deviation of 32.13 ± 1.21 and a coefficient of variability of 50.35 ± 1.89 per cent.

The oil content of grass cut at different ages and the actual yield from one hectare of citronella grass were determined by the Calamba Sugar Estate. They are summarized by the author as follows:

CROP NO.	AGE OF CROP	TOTAL WEIGHT OF CUT LEAVES	TOTAL AMOUNT OF OIL OBTAINED	OIL CONTENT
	months	*kgms.*	*kgms.*	*per cent*
1	7	7095.0	31.490	0.444
2	4	3277.2	16.032	0.489
3	5	1956.9	15.880	0.811

According to the writer's collaborators at the Calamba Sugar Estate, "A representative sample of the Calamba Sugar Estate citronella oil from the first crop was submitted to Messrs. Curtis and Thompkins, Ltd., Analytical and Engineering Chemists, San Francisco, and it gave the following analysis:

Total geraniol and citronella expressed as total geraniol ..... 85.0 per cent

"We were advised that this value was as high as that obtained for Java citronella oil, which is considered to be the best quality in the U. S. A.

"Samples from the second crop were submitted to the Bureau of Science in Manila and gave the following analysis:

Total acetylizable constituents expressed as geraniol	No. 1	88.0	per cent
	No. 2	92.3	per cent

"Citronella oil for export should be guaranteed pure and should contain not less than 85.0 per cent 'geraniol'."

The results of the analysis of the oil extracted from thirteen month old citronella grass at different periods of air drying indicated that the highest oil yield came from the leaves air dried for six days after harvesting. If drying was extended to eight or ten days, a decrease in the oil content was observed.

No significant difference seemed to occur between the oil content of leaves cut from plants which produced flowers and from plants which had no flowers.

SUMMARY

1. The cost of planting and harvesting citronella grass per hectare is ₱109.90.

2. The yield of citronella grass per hectare obtained at the Calamba Sugar Estate was 7095.0 kilograms from seven month old plants, 3277.2 kilograms from four month old plants, and 1956.9 kilograms from five month old plants.

3. The amount of oil extracted from leaves of plants in one hectare was 31.490 kilograms for leaves cut after seven months; 16.032 kilograms for those, after four months; and 15.880 for those, after five months.

4. Of the cut leaves analyzed for oil content at varying ages after planting, those which were cut after five months yielded the highest percentage of oil, 0.811 per cent.

5. The oil extracted from the leaves of plants grown at the Calamba Sugar Estate analyzed from 85.0 to 92.3 per cent total geraniol.

TABLE 1

Average rainfall and temperature in the Calamba Sugar Estate and College of Agriculture, where citronella grass has been tried

MONTH	AVERAGE RAINFALL		AVERAGE TEMPERATURE					
			Maximum		Minimum		Mean	
	Canlubang	College	Canlubang	College	Canlubang	College	Canlubang	College
1938	*inch*	*inch*	*°C.*	*°C.*	*°C.*	*°C.*	*°C.*	*°C.*
January	1.96	2.29	28.8	29.1	21.5	21.7	25.2	25.4
February	0.20	0.01	31.0	31.3	21.8	21.9	26.4	26.6
March	0.25	5.00	32.4	32.5	23.2	22.7	27.8	27.6
April	5.70	6.99	31.9	32.7	24.4	23.4	28.1	28.1
May	8.17	14.93	32.3	32.8	24.2	23.3	28.2	28.1
June	14.01	9.16	31.3	31.9	24.0	23.7	27.6	27.8
July	14.38	8.55	31.2	32.1	23.5	23.3	27.4	27.7
August	12.03	3.91	32.7	33.1	23.9	23.5	28.3	28.3
September ...	12.34	10.40	31.4	31.8	23.6	23.5	27.5	27.6
October	17.21	9.56	30.4	30.8	23.2	23.2	26.8	27.0
November	19.27	18.26	29.0	29.2	22.9	23.1	25.9	26.1
December	4.67	6.01	28.8	28.5	22.4	22.7	25.6	25.6

TABLE 2

Variation of weight of green leaves and number of culms per hill of citronella grass at the age of one year, four months, and four days grown in the College of Agriculture Experiment Station

WEIGHT OF GREEN LEAVES		NUMBER OF CULMS	
Class range	Frequency	Class range	Frequency
kgm.			
0.1– 1.0	22	5– 19	13
1.1– 2.0	32	20– 34	17
2.1– 3.0	40	35– 49	29
3.1– 4.0	21	50– 64	31
4.1– 5.0	23	65– 79	19
5.1– 6.0	5	80– 94	23
6.1– 7.0	5	95–109	16
7.1– 8.0	6	110–124	9
8.1– 9.0	3	125–139	0
9.1–10.0	2	140–154	3
10.1–11.0	1	155–169	1
11.1–12.0	1	—	—
Total	161	Total	161
Mean .	3.21±0.12 kgm.		63.71±1.71 culms
S. D. ..	2.21±0.08 kgm.		32.13±1.21 culms
C. V. ..	68.84±2.58 per cent		50.35±1.89 per cent

TABLE 3

Percentage of oil extracted from thirteen month old citronella grass by the Department of Agricultural Chemistry, College of Agriculture

WEIGHT OF SAMPLE	NUMBER OF DAYS AIR DRIED	AMOUNT OF OIL OBTAINED	YIELD
grams	*days*	*grams*	*per cent*
650	0	3.2858	0.505
830	2	5.4680	0.650
820	4	5.4600	0.660
663	6	6.6920	1.090
615	8	5.9820	0.970
509	10	2.8637	0.560
800	Fresh, with flowers	3.9190	0.480
900	Fresh, without flowers	3.8268	0.420

TABLE 4

Oil extraction by Calamba Sugar Estate from citronella grass at different ages

CROP NO.	AGE	AREA PLANTED	NUMBER OF STOOLS	TOTAL WEIGHT OF CUT LEAVES	WEIGHT OF CUT LEAVES PER STOOL	TOTAL AMOUNT OF OIL OBTAINED	OIL CONTENT	AMOUNT OF OIL PER STOOL
	months	*Ha.*		*kgm.*	*kgm.*	*kgm.*	*per cent*	*grams*
1	7	0.6	4004	4257	1.063	18.885	0.444	4.72
2	4	4.3	35094	14092	0.402	68.940	0.489	1.96
3	5	4.3	38950	8415	0.216	68.285	0.811	1.75

STUDIES ON THE STRENGTH OF RENNET EXTRACT PRODUCED FROM THE STOMACH OF PIGS[1]

CECILIO B. ANTONIO

WITH TWO TEXT FIGURES

The rennet extract used for curdling milk contains the enzyme rennin, which precipitates casein. While similar enzymes are found in the pancreas and simple stomachs of many animals as well as in some plants, according to Rogers' associates (1935) the commercial rennet extract used by cheese makers today is prepared from the fourth stomach of calves and lambs.

In view of the fact that pigs are more available in the Philippines, easier to produce, and better adapted to butchering at an earlier age than calves, it seems important to know whether it is possible to make rennet extract from the stomach of pigs.

The writer is not aware of any work on the use of the stomach of pigs as a source of rennet extract. Published work on commercial rennet extract deals mostly with methods of preparation of this product from the fourth stomach of calves.

In New Zealand (Anon., 1916), the commercial rennet extract is prepared from the fourth stomach of three to four day old calves. After the stomach has been carefully emptied of its contents, the adhering parts, such as fat and other tissues, are removed. Then it is inflated with air, hung in a room, and dried in the air, but not directly in the sun. Care is taken to prevent infestation of the fresh stomach by maggots and the growth of molds because these hinder thorough and successful drying. Drying may be completed in about a week depending upon the temperature of the atmosphere and the velocity of the wind. When the stomach is thoroughly dried, the air is removed from it and the dry tissue stored. These dried stomachs are tied in bundles and sent to the factory for rennet extraction.

Barthel and Goodwin (1910) prepared rennet extract from the fourth stomach of suckling calves in the following manner: The fresh stomach was emptied, not washed, inflated with air, air dried, and

[1] Experiment Station contribution No. 1388. Prepared in the Department of Animal Husbandry under the direction of Assistant Professors Felix B. Sarao and Mariano Mondoñedo.

then stored for three months. After that time, the parts of the dried stomach with no folds were removed. The rest was cut into square, one centimeter pieces. One hundred grams of these pieces were placed in a liter of water and 50 grams of salt and 40 grains, or about three grams, of boric acid were added. The mixture was allowed to stand for five days at room temperature. After 50 grams more of salt were added, the extract was filtered off and used for coagulating milk.

Heineman (1921) states that the rennet extract for coagulating milk is obtained from the glandular part of the fourth stomach of suckling calves. The calf is milk-fed for twelve hours before slaughtering. After the calf is killed, the stomach is removed, washed with water, and sprinkled with salt. The stomach is inflated with air and air-dried. The glandular part of the stomach is scraped off and the scrapings digested with ten to twenty times their volume of 0.2 per cent hydrochloric acid. The acid is neutralized before the rennet extract is used.

Wing (1909) reports that the active principle of rennet extract is found in the inside lining of the folds of the fourth stomach of calves. In contrast to Heineman (1921), he states that rennet is in greatest amount when extracted from the fourth stomach of calves which have been given a full meal three or four hours before slaughtering. In Wing's description, the stomach was cleaned, turned inside out and sprinkled with salt, then stretched and air-dried. The dried stomach was soaked in water and the resulting extract was filtered off and was ready for use.

Shelton (1928) found that rennet extract is of a delicate nature and is subject to depreciation in strength if exposed to heat or direct sunlight. The strength of rennet extract is also impaired by the presence of any alkaline substance which has inhibitory effect on the rennet action of coagulating milk.

The objects of this work were: (*a*) to determine the relation of the age of a pig to the curdling power of the rennet extract obtained from its stomach, and (*b*) to compare the curdling power of rennet extract as affected by the length of storage of the dried pig's stomach.

The studies were conducted in the Department of Animal Husbandry from October 1, 1931, to February 7, 1933.

Plan of the study

Ninety-four Berkjala swine ranging in age from one day to approximately two years were used in this study. All of them were in

good condition. In testing the curdling power of rennet extract produced from the stomach of these pigs, milk from only one breed of dairy cattle was used throughout the experiment.

After the stomach was separated from the rest of the internal organs, the contents were removed. The stomach was cleaned by being filled with water through the duodenal opening and emptied of the wash water by pressing the sides. Before the stomach was inflated, the cardiac opening was ligated with a string. A short rubber tubing was inserted through the pyloric opening to facilitate

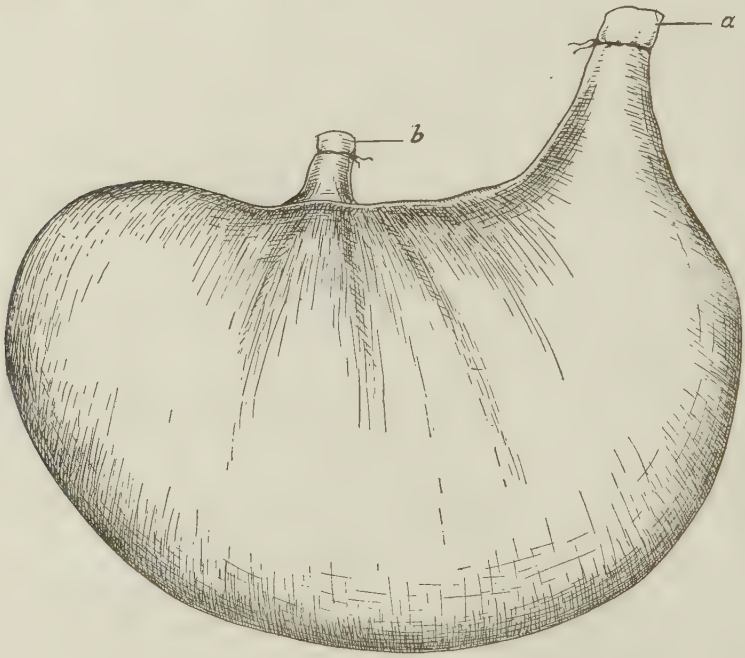

Fig. 1—Stomach of the pig with (a) oesophageal opening and (b) duodenal opening tied after inflation.

blowing of air into it. When the stomach was sufficiently inflated, the rubber tubing was removed and the opening was closed tightly (fig. 1). As soon as the fatty and other tissues adhering to the sides had been removed, the inflated stomach was hung in the shade to dry.

The stomach of mature pigs when treated in this manner could not be successfully dried without getting moldy. The outer muscular layer had to be removed before being hung up to dry. In some cases the stomach could not be inflated when treated thus. It was then cut open, stretched on a smooth piece of wood, and dried.

To prevent infestation by maggots, the stomach was dried in a screened cage. After drying, the stomach was kept in a tightly sealed mason jar.

Artesian well water was used as the sole medium for rennet extraction. For each test, a 4 sq. cm. portion of each stomach was taken and placed in 100 cc. of water in a half pint milk bottle where it was kept for 24 hours before the rennet extract was obtained for testing.

As preliminary trials have shown that the pyloric region of the stomach yielded the more potent rennet, only rennet extract from this part of the stomach was used in the comparative studies. Figure 2 is a longitudinal section of a mature pig's stomach showing the rela-

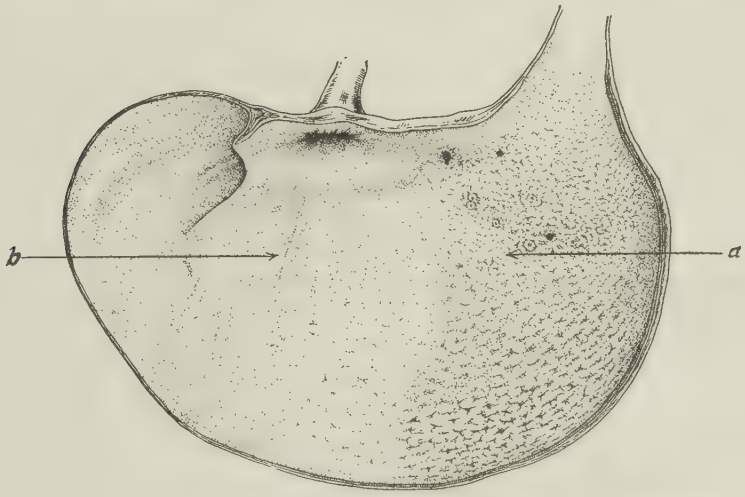

Fig. 2—Interior of the stomach of the pig showing (a) cardiac and (b) pyloric gland regions.

tive proportion of the cardiac and pyloric regions. At every two week interval, rennet was extracted from a piece of each stomach to find out whether or not the curdling power of rennet was affected by length of storage of the dried stomach.

Samples were taken from newly drawn milk. That representative samples might be obtained, the milk was transferred from one container to another several times before each 100 cc. sample was taken and placed in a half pint milk bottle. Each rennet extract prepared was tested in duplicate. For control, a third sample of milk to which no rennet extract was added was allowed to coagulate naturally. The time required to coagulate the milk by the rennet extract produced from the stomach of each pig compared with the

time required for the milk to curdle naturally was taken as the strength of curdling power of the rennet extract. The period from the time the rennet was added to the time the milk was completely coagulated was considered the required time. The milk was considered completely coagulated as soon as the whey turned clear and light straw-colored.

For purposes of further comparison another set of the same kind of milk samples was prepared. To each of these, 4 cc. of 10 per cent solution of Hansen's Danish commercial rennet extract was added. The 10 per cent solution was prepared by adding 10 cc. of the concentrated commercial rennet extract to 90 cc. of water from the same source used in the extraction of the rennet from the stomach of a pig.

The number of observations made at two week intervals on the effect of length of storage on the curdling power of the rennet extract from each dried stomach could not possibly be the same because the stomachs of younger pigs are smaller than those of older ones. For example, the stomachs of one day old pigs could be used up to only ten weeks after drying, the stomachs of from two to six week old pigs, which were larger, could be tested up to fourteen weeks after drying and so on. The stomachs of mature pigs provided sufficient materials for use up to eighteen weeks after drying.

DISCUSSION OF RESULTS

Relation of the age of a pig to the curdling power of the rennet extract produced from its stomach

Table 1 shows that the curdling power of the rennet extract decreased as the pig grew older. In general the rennet extract of one day old to two week old pigs showed the greatest potency. The strongest rennet extract was obtained from the stomachs of one day old pigs. These were 4.51 and 4.44 per cent, respectively, as strong as an equal amount of 10 per cent Hansen's Danish commercial rennet extract. Unfortunately pigs are not usually slaughtered until they are much older than two weeks; hence if young pigs are to be used as sources of rennet, they will have to be slaughtered solely for that purpose. This is not economical. The average age at which pigs are slaughtered for *lechon* is twelve weeks and the age at which they are usually slaughtered for pork is about fifty-two weeks. The rennet extract produced from twelve week and fifty-two week old pigs was 2.49 and 1.22 per cent, respectively, as strong as the 10 per cent commercial rennet extract. If a systematic effort can be made to

save the stomachs from twelve week and fifty-two week old pigs, a very considerable amount of rennet extract can be produced.

Effect of length of storage of dried stomach on the curdling power of the rennet extract produced from it

Table 2 shows that the curdling power of rennet extracted from dried pig stomachs that had been kept under storage from ten to eighteen weeks did not vary greatly. There was no uniformity in the length of time required to curdle milk with the rennet from the same stomach treated at different periods; the variations were not only slight but also inconsistent. For example, immediately after drying, the rennet extracted from a one day old pig coagulated the milk in 443 minutes; two weeks after drying, in 470 minutes; and four weeks after drying, in 438 minutes, or five minutes shorter than the time required to curdle the same kind and quantity of milk in the previous test. Similar variations were also noted in the case of the rennet extracted from the stomach of pigs of other ages. For example, the time required to coagulate the milk samples with rennet from 36 week old pigs after the stomachs had been ten weeks in storage was 1,468 minutes; after twelve weeks, 1,427 minutes; after fourteen weeks, 1,463 minutes; after sixteen weeks, 1,467 minutes; and after eighteen weeks, 1,450 minutes. Statistical treatment of the curdling power, or the time required to curdle the milk, of the rennet extracted from each stomach at different periods gave probable errors ranging from $\pm$ 1.36 minutes of the mean of 480.43 minutes for one week old pigs to $\pm$ 6.89 minutes of the mean of 1,430.60 minutes for 36 week old pigs. The fluctuations as affected by length of storage of the dried stomachs of the same ages were probably due to factors other than length of storage, such as, variation in temperature of the room each time a set of tests was made. This statement finds a basis in the results obtained from the control, which had a mean curdling time of 1,936.90 $\pm$ 6.55 minutes. Therefore, to avoid significant fluctuations in the time required for curdling, it would seem desirable to place the milk in a place where the temperature is not subject to great variations.

SUMMARY AND CONCLUSIONS

1. Rennet extract was produced from the stomach of swine ranging in age from one day to fifty-two weeks. The greatest concentration of rennet was obtained from the pyloric gland region. The extract from the cardiac gland region of the stomach had very slight curdling power.

2. On the average, rennet extracted from one day old pigs coagulated the milk in about 443 minutes (7 hours and 23 minutes); from two week old pigs, in 483 minutes (8 hours and 3 minutes); from twelve week old pigs, in 803 minutes (13 hours and 23 minutes); from twenty-four week old pigs, in 1,143 minutes (19 hours and 3 minutes); from thirty-six week old pigs, in 1,383 minutes (23 hours and 3 minutes); and from fifty-two week old pigs, in 1,638 minutes (27 hours and 18 minutes).

3. When the air-dried stomachs were kept in properly sealed mason jars from ten to eighteen weeks, the curdling power of the rennet extracted from them did not decrease.

4. When the curdling power of the rennet from each stomach extracted immediately after drying was compared with that of the 10 per cent Hansen's Danish commercial rennet extract, it was found that the rennet from one day old pigs was 4.51 per cent as strong as the latter; from one week old, 4.16 per cent; from twelve week old, 2.49 per cent; from twenty-four week old, 1.75 per cent; from thirty-six week old, 1.45 per cent; and from fifty-two week old, 1.22 per cent. The strength of the rennet extract from the stomachs of pigs can be raised to the level of that of the Hansen's Danish commercial rennet extract by increasing the proportion of the weight of dried stomach to the volume of the medium used for extraction.

5. Rennet extract from the stomachs of very young pigs may be used for curdling milk, but its use is limited by the fact that very young pigs are not generally killed for consumption. Pigs for *lechon* at about twelve weeks of age and mature hogs are the practical sources of material for the manufacture of commercial rennet extract.

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TABLE 1

Average relative strength of rennet extract produced from the pyloric region of the stomach of pigs of different ages as compared with ten per cent Hansen's Danish commercial rennet extract

AGE OF PIG	TIME REQUIRED TO COAGULATE THE MILK	STRENGTH AS COMPARED WITH TEN PER CENT HANSEN'S DANISH COMMERCIAL RENNET EXTRACT
	min.	*per cent*
1 day	443	4.51
2 days	450	4.44
1 week	481	4.16
2 weeks	483	4.14
4 "	651	3.07
6 "	650	3.08
8 "	703	2.84
10 "	740	2.70
12 "	803	2.49
14 "	946	2.11
16 "	1,040	1.92
20 "	1,034	1.93
24 "	1,143	1.75
28 "	1,167	1.71
32 "	1,342	1.49
36 "	1,383	1.45
40 "	1,535	1.30
44 "	1,580	1.26
48 "	1,640	1.22
52 "	1,638	1.22
Ten per cent Hansen's Danish commercial rennet extract	20	100.00

TABLE 2

Average strength of rennet extract produced from the pyloric region of the stomach as affected by the age and by the length of storage after drying

AGE OF PIG	TIME REQUIRED TO COAGULATE THE MILK SAMPLES										MEAN	PROBABLE ERROR OF THE MEAN
	Immediately after drying	2 weeks after drying	4 weeks after drying	6 weeks after drying	8 weeks after drying	10 weeks after drying	12 weeks after drying	14 weeks after drying	16 weeks after drying	18 weeks after drying		
	min.	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*
1 day	443	470	438	455	463	453					453.67	± 3.29
2 days	450	435	453	450	458	460					451.00	± 2.45
1 week	481	472	482	483	487	480					480.43	± 1.36
2 weeks	483	477	480	494	489	498	493	480			486.75	± 1.85
4 "	651	664	663	653	671	643	657	690			661.50	± 3.44
6 "	650	660	658	639	650	639	647	628			646.38	± 2.56
8 "	703	709	698	694	695	692	704	702	730		703.00	± 2.59
10 "	740	722	745	742	737	755	741	744	760		742.89	± 2.42
12 "	803	808	822	816	799	824	826	831	862		821.22	± 4.22
14 "	946	950	944	947	948	942	938	952	960		947.44	± 1.40
16 "	1,040	1,055	1,061	1,047	1,044	1,051	1,059	1,078	1,051		1,054.00	± 2.47
20 "	1,033	1,071	1,086	1,083	1,100	1,102	1,097	1,100	1,101		1,085.89	± 5.04
24 "	1,143	1,162	1,167	1,176	1,186	1,196	1,189	1,197	1,193		1,178.77	± 4.12
28 "	1,167	1,177	1,197	1,167	1,197	1,196	1,207	1,213	1,219	1,215	1,195.50	± 4.11
32 "	1,342	1,397	1,387	1,403	1,390	1,367	1,388	1,382	1,448	1,438	1,394.20	± 6.60
36 "	1,383	1,408	1,386	1,412	1,442	1,468	1,427	1,463	1,467	1,450	1,430.60	± 6.89
40 "	1,535	1,537	1,560	1,517	1,518	1,475	1,508	1,508	1,520	1,536	1,521.40	± 4.86
44 "	1,580	1,607	1,612	1,557	1,617	1,627	1,598	1,568	1,617	1,595	1,597.80	± 4.90
48 "	1,640	1,613	1,640	1,652	1,663	1,683	1,655	1,652	1,627	1,645	1,647.00	± 4.10
52 "	1,638	1,655	1,603	1,690	1,648	1,637	1,670	1,658	1,673	1,665	1,653.70	± 5.14
Control (natural coagulation)	1,967	1,948	1,966	1,974	1,930	1,931	1,930	1,869	1,915	1,939	1,936.90	± 6.55

A STUDY OF CERTAIN CHEMICAL AND BIOLOGICAL PROPERTIES OF DIFFERENT SOIL MEDIA[1]

D. I. AQUINO AND S. T. ANCHETA
Of the Department of Soils

WITH FIVE TEXT FIGURES

The seasonal accumulation of nitrates in the soil is important because nitrate is one of the forms of nitrogen readily available to plants. According to Waksman and Madhok (1937), several factors influence the nitrate-nitrogen content of the soil. Drying the soil increases the amount of nitrate nitrogen that can be extracted from it. Biological oxidation of ammonia to nitrite and of nitrite to nitrate is important in the formation of nitrate in the soil.

A very acidic soil is detrimental to the growth of crops. In humid regions or in places where rainfall is very abundant, the soil tends to become acidic. According to Aquino (1931), continuous application of sulfur also increases the acidity of the soil.

Cellulose is of value when added to the soil. The efficiency of a soil to decompose organic materials incorporated with it is important. Aquino and Tabije (1933) state that the more fertile the soil is the faster the decomposition of organic matter and subsequent liberation of nitrogen.

Sulfur is assimilated by plants in the form of sulfates; hence, a high sulfur-oxidizing power of a soil should be maintained in order to supply adequately the needs of the crop. Aquino (1931) claims that the amount of sulfur added to the soil and the number of sulfofying bacteria in it have a direct relation to the sulfur-oxidizing capacity of that soil.

This study was undertaken to determine: (*a*) the seasonal accumulation of nitrates, (*b*) hydrogen-ion concentrations, (*c*) cellulose-decomposing capacity, and (*d*) sulfofying power of various soils.

REVIEW OF LITERATURE

According to Gowda (1924), an increase in moisture content at certain dates of sampling coincides with the decrease in the nitrate-nitrogen content of the soil.

[1] Experiment Station contribution No. 1389.

Punyasingh [2] found that there was a rather distinct irregular fluctuation of the nitrate-nitrogen content of the different soil media at different dates of sampling. He states that the moisture content of the soil influences greatly the concentration of nitrates at different times of the year. Hall (1924) also believes that the amount of nitrates at different seasons is influenced by the leaching effects of heavy rain as well as by excessive amounts of soil moisture.

Mukerji (1924) found that the distribution of nitrates in the surface and subsoil layers is determined by their physical characters and their meteorological factors. He states that the growth of crops depends to a certain extent on the distribution of nitrates.

Fraps (1920) believes that the quantity of nitrates produced in the soil depends upon its physical condition and chemical composition. According to Bear (1929), good drainage, frequent cultivation, adequate supply of water, and warmth are essential to the production of nitrates in the soil.

Sison [3] found that the hydrogen-ion concentration of some forest soils did not show any correlation with the nitrate-nitrogen content of the soil.

Aquino (1931) believes that soils have a definite sulfur-oxidizing efficiency, which varies with different treatments. He found that a greater sulfur-oxidizing power is brought about by the addition of sodium thiosulfate rather than elemental sulfur.

Ames and Boltz (1916) found that plots treated with sulfur-bearing fertilizers for a number of years contain more sulfur than untreated soils, although cropped in a similar manner.

MATERIALS AND METHODS

The soil samples used in the study of the seasonal accumulation of nitrates, hydrogen-ion concentration (pH values), cellulose decomposition, and sulfur oxidation were collected at regular intervals from

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[2] PUNYASINGH, THONGJAYA. A preliminary study of the seasonal variations of nitrate-nitrogen in the coffee plantation soils of the College of Agriculture. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1934. Unpublished.)

[3] SISON, BARTOLOME J. Studies of the nitrate assimilating power of some forest soil. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1933. Unpublished).

the experimental plots of the Division of Olericulture, Department of Agronomy.

Soil media used in the different plots

NO. OF PLOTS	COMPOSITION OF THE MEDIA
1	Surface soil
2	Compost
3	Silt loam
4	Compost
5	Surface soil
6	½ sand, ½ surface soil
7	½ sand, ½ surface soil
8	¼ sand, ¾ surface soil
9	¼ sand, ¾ surface soil
10	Pure sand
11	¾ sand, ¼ surface soil

The phenoldisulfonic acid (colorimetric) method of Emerson (1927) was followed for determining the nitrate-nitrogen content of the various soil samples.

The quinhydrone pH indicator was used for the determination of the hydrogen-ion concentration of the different soil samples.

The cellulose-decomposing ability and sulfofying power of the soils collected from the different plots were determined by methods suggested by Fred and Waksman (1928).

EXPERIMENTAL RESULTS

The monthly variations of the nitrate-nitrogen contents of the various soil media are presented in table 1.

Table 2 shows the hydrogen-ion concentration (pH values) of the different soil media.

The different amounts of cellulose decomposed by the various soil samples are presented in table 3.

Table 4 shows the amounts of sulfur as sulfates in the variously treated plots.

Figure 1 shows the relation of rainfall to the seasonal accumulation of nitrate-nitrogen during the entire period of investigation. The data on rainfall were secured from the Department of Agricultural Botany, College of Agriculture.

The fluctuation of the nitrate-nitrogen content of the soils from the different plots at different dates are shown in figure 2. Figure 3 shows the nitrate-nitrogen content of the different soil media.

The relation between the nitrate-nitrogen content and cellulose-decomposing capacity of the different soil media is illustrated in figure 4.

Figure 5 shows the relations of the nitrate-nitrogen content, cellulose decomposing capacity, pH values, and sulfofying power of the different soil media.

DISCUSSION OF RESULTS

Nitrates in the soil. Table 1 and figure 3 show that the soil samples collected from the different plots showed significant differences in their nitrate-nitrogen content. The average figures of nitrogen as nitrates show that plots 2 and 4 where compost had been

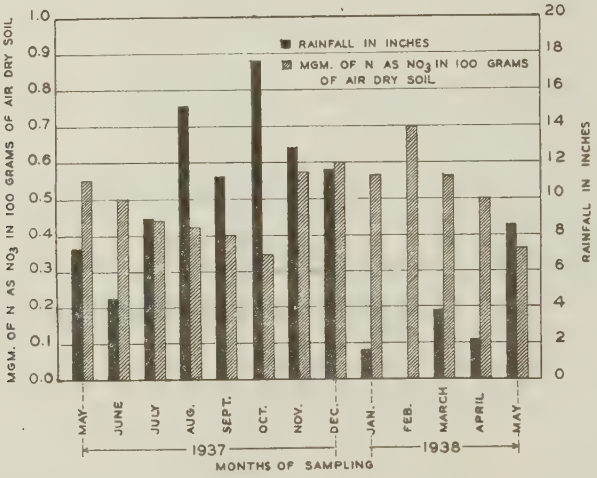

Fig. 1.—The relation of rainfall to seasonal accumulation of nitrate-nitrogen during the entire period of the investigation.

used had the highest nitrate-nitrogen content. Plots 5, 8, and 9 showed a rather insignificant difference in their nitrate-nitrogen content. Relatively low amounts of nitrates were shown by the soil samples collected from plots 1, 3, 6, 7, and 11. The smallest amount of nitrate-nitrogen was shown by the sample collected from plot 10. Aquino and Javier (1932) observed that different soil types showed a very distinct variation in their nitrate-nitrogen content. These authors claimed that this variation may be attributed to variation in soil reaction, topography, soil type, vegetation, system of cropping, and distribution of microbiological flora in the soil. Fraps (1920) also concluded that the quantity of nitrates produced in the soil de-

pends upon the physical condition and chemical composition of the soil.

The results seem to indicate also that a rather distinct irregular fluctuation of the nitrate-nitrogen content of the different soil media at different dates of sampling occurred. The soil samples collected in May, June, November, and December, 1937, and in January, February, March, and April, 1938, showed large amounts of nitrogen in the form of nitrates. Relatively small amounts of nitrates were found in soil samples collected in July, August, September, and October, 1937, and in May, 1938. The soil samples collected in February showed the highest amount of nitrate-nitrogen. The lowest amount

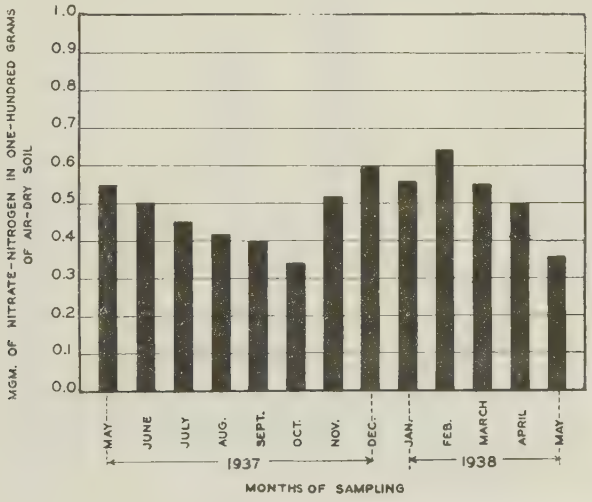

Fig. 2.—Nitrate-nitrogen contents of soils at different dates of sampling.

of nitrate-nitrogen was shown by the sample collected in October, 1937.

The fluctuation of nitrate-nitrogen content of the soils at different samplings may be attributed to irregular distribution of rainfall at different seasons. Figures 1 and 2 show that, in most cases, an increase in moisture content during certain periods of sampling coincided with a decrease in the nitrate-nitrogen content of the soil. This corroborates the findings of Gowda (1924) and Punyasingh.[4] Batham (1925) and Batham and Nigam (1930) also state that the nitrates in the soil fluctuate regularly at definite periods. The great-

[4] Footnote [2].

est quantity of nitrates may be found during the summer months and the least during the winter.

Hydrogen-ion concentrations. Table 2 shows that the soils from each of the eleven plots differed slightly in their reactions. Plots 2, 3, 4, and 10 gave an alkaline reaction and the rest slightly acidic.

Table 1 and figure 5 also show that the soil from plot 4 had the greatest amount of nitrates, whereas the soils from plot 10 had the least. A similar case may be observed in plots 2 and 3, which showed very insignificant variation in hydrogen-ion concentration. These

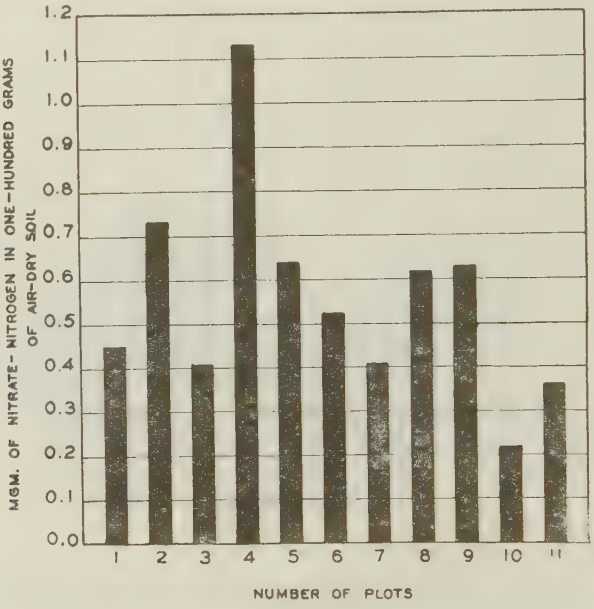

Fig. 3.—Nitrate-nitrogen contents of the soil in the different plots.

two plots differed markedly in their nitrate-nitrogen content. It seems that the hydrogen-ion concentration of the various soil samples did not have any definite relation to their nitrate-nitrogen content. Sison [5] and Punyasingh [6] also observed that the hydrogen-ion concentrations have no relation to the nitrate-nitrogen content of the soil.

Cellulose decomposition in soils. The number of grams of cellulose decomposed per hundred grams of air-dry soil is presented in table 3. Table 3 shows that the soils from the different plots varied

[5] Footnote [3].
[6] Footnote [2].

in their ability to decompose cellulose. Plots 1, 2, 4, and 5 showed the greatest amount of cellulose decomposed and plots 6, 7, 10, and 11, the least. Plots 3, 8, and 9 showed insignificant differences in their cellulose-decomposing capacity. Compost soils showed the highest amount of cellulose decomposition, and as to be expected, pure sand in plot 10 showed the least. Aquino and Tabije (1933) state that the organic matter content of the soil and its bacterial population greatly influence cellulose decomposition. Compared with the control, the variously treated samples showed a significant cellulose-decomposing capacity.

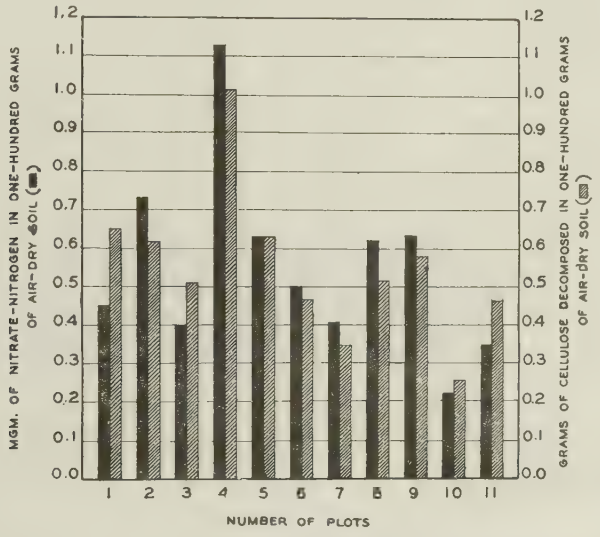

Fig. 4.—Relation between the nitrate-nitrogen contents and the cellulose-decomposing capacity of the different soil media.

The cellulose-decomposing capacity of the various soils showed a distinct relation to the nitrate-nitrogen content. In the majority of cases, an increase in nitrate-nitrogen was followed by a more pronounced cellulose-decomposing power (fig. 4). This is in accord with the results secured by Aquino and Tabije (1933).

Sulfofication studies. The sulfofying power of the various soil samples is shown in table 4 and in figure 5. The data reveal that the different soil samples varied in their sulfofying ability. The untreated compost soils in plots 2 and 4 gave the greatest amount of sulfur in the form of sulfates. When one gram of elemental sulfur was added to the same soil, it gave the smallest amount of sulfates.

A still greater sulfur oxidizing power was observed when four grams of sodium thiosulfate were added to the soil than when elemental sulfur was used.

In table 4 and figure 5 the amount of sulfate from the different plots fluctuated irregularly. The fluctuation, however, did not show any relation to the amounts of nitrates present and to cellulose decomposition.

SUMMARY AND CONCLUSIONS

1. There was an irregular fluctuation of nitrates in the soil from the different plots at different dates. The highest amount of nitrates was present in the samples collected in February, 1938, and the least was noted in those collected in October, 1937.

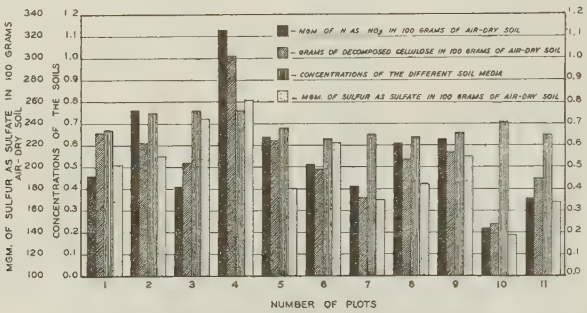

Fig. 5.—Relation of nitrate-nitrogen contents, cellulose-decomposing capacity, pH value, and sulfofying power of the different soil media.

2. Rainfall and soil moisture influenced the accumulation of nitrates. Owing to leaching the increased moisture resulted in decrease in nitrates.

3. No correlation existed between the amount of nitrate-nitrogen and the hydrogen-ion concentration of the different soil samples.

4. Although the variously treated samples differed in their ability to decompose cellulose, all of them had a high cellulose-decomposing capacity. As was expected compost soil showed the highest cellulose decomposition, and pure sand the least. A close correlation existed between the cellulose-decomposing capacity and the nitrate-nitrogen content of the soils.

5. All the variously treated soil differed in their sulfofying power. The slightly alkaline soils with elemental sulfur treatments showed greater sulfofying power. In most cases, samples treated

with four grams of sodium thiosulfate showed a still greater oxidizing power than those treated with one gram of elemental sulfur.

6. No correlation was noted between the sulfofying power, nitrate-nitrogen content, and cellulose-decomposing ability of the soils studied.

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TABLE 1

Monthly variation of the amounts of nitrate-nitrogen expressed in milligrams per hundred grams of air-dry media (May to December, 1937, and January to May, 1938)

NO. OF PLOTS	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
1	0.560	0.599	0.472	0.441	0.447	0.389	0.433
2	0.855	0.824	0.515	0.479	0.453	0.483	0.455
3	0.478	0.399	0.384	0.427	0.403	0.446	0.410
4	1.648	1.406	1.195	1.022	0.706	0.608	1.201
5	0.617	0.507	0.546	0.498	0.507	0.426	0.563
6	0.384	0.397	0.363	0.374	0.375	0.319	0.681
7	0.364	0.333	0.323	0.319	0.327	0.370	0.660
8	0.502	0.449	0.444	0.426	0.479	0.400	0.681
9	0.532	0.386	0.423	0.410	0.540	0.405	0.540
10	0.084	0.091	0.077	0.070	0.062	0.060	0.309
11	0.149	0.151	0.154	0.145	0.099	0.093	0.373
Averages	0.559	0.503	0.445	0.419	0.399	0.355	0.537

NO. OF PLOTS	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	AVERAGE PER PLOT
1	0.181	0.441	0.320	0.208	0.195	0.209	0.445
2	0.512	0.502	0.595	0.944	0.785	0.605	0.728
3	0.171	0.204	0.288	0.242	0.361	0.204	0.401
4	1.075	1.170	0.864	1.750	1.125	0.685	1.132
5	1.005	0.567	0.543	0.464	0.483	0.215	0.631
6	1.588	0.296	0.343	0.283	0.136	0.120	0.514
7	0.483	0.329	0.404	0.318	0.205	0.154	0.414
8	0.339	0.440	0.090	0.462	0.586	0.506	0.619
9	0.693	0.350	1.331	0.613	0.715	0.950	0.626
10	0.230	0.385	0.595	0.370	0.267	0.156	0.212
11	0.250	0.580	0.634	0.485	0.587	0.168	0.351
Averages	0.593	0.569	0.637	0.558	0.495	0.370	

TABLE 2

Hydrogen-ion concentrations (pH values) of the soil in each plot [a]

NUMBER OF PLOTS	PH VALUES
1	6.61
2	7.20
3	7.25
4	7.50
5	6.75
6	6.65
7	6.75
8	6.70
9	6.80
10	6.05
11	6.75

[a] Averages of duplicate determinations.

TABLE 3

Amount of cellulose decomposed in grams per one hundred grams of air-dry soil

NUMBER OF PLOTS	CONTROL	ONE GRAM OF FILTER PAPER ADDED
1	0.0880	0.6520
2	0.0990	0.6210
3	0.0510	0.5060
4	0.1840	0.0045
5	0.0980	0.6205
6	0.0465	0.4780
7	0.0435	0.3520
8	0.0505	0.5175
9	0.0615	0.5770
10	0.0070	0.2085
11	0.0525	0.4615
Averages	0.0710	0.5453

TABLE 4

Amount of sulfur as sulfates in milligrams per one hundred grams of air-dry soil

NUMBER OF PLOTS	TREATMENTS OF SOIL SAMPLES		
	Control	One gram of sulfur added	Four grams of sodium thiosulfate added
1	55.00	146.00	291.00
2	70.00	248.00	174.00
3	55.40	210.00	273.00
4	91.70	241.20	282.00
5	57.40	188.00	170.00
6	59.00	178.00	267.00
7	56.00	198.00	148.00
8	58.40	181.20	188.00
9	60.00	164.00	258.00
10	52.60	122.40	131.30
11	54.60	148.10	182.60
Averages	60.92	184.08	214.98

A TEST OF SOME WRAPPER TOBACCO VARIETIES [1]

EULALIO P. BALTAZAR AND PIO A. TADINA
Of the Department of Agronomy

The Philippines is a tobacco growing as well as a cigar and cigarette manufacturing country. Every year large quantities of wrapper leaf tobacco are imported into the Philippines for the manufacture of expensive cigars. As wrapper leaf tobacco is badly needed by the Manila cigar factories, it is necessary to grow it locally.

According to Mr. Antonio Peña, Chief of the Division of Statistics, Department of Agriculture and Commerce, the Philippines in 1939 imported 656,634 kilos of leaf tobacco, valued at ₱917,765.00. According to the managers of tobacco factories in Manila, the wrapper leaf tobacco that they are using for the manufacture of cigars comes from Sumatra, Porto Rico, Havana, Georgia, and Connecticut.

One way to reduce the large importation of wrapper leaf tobacco in the Philippines is to raise it in this country. The prospect of growing wrapper tobacco here seems to be bright because the soil and climatic conditions are favorable for the crop. As a matter of fact, the Philippines should be able to produce wrapper leaf tobacco cheaper than Connecticut or Georgia because labor in the Philippines is much cheaper than in the United States.

Not much work has been done on the production of wrapper leaf tobacco on a large scale in the Philippines. Paguirigan and Tugade [2] believe that Simmaba wrapper tobacco variety was originally found in La Union. It is said to be the best wrapper tobacco variety for shade-culture in that place. They also state that Vizcaya was originally found in Cagayan, and it is now extensively grown in Ilagan Experiment Station, Isabela.

The work reported in this paper was an attempt to grow wrapper leaf tobacco without the use of artificial shade so as to minimize the cost of production of the crop. Four known local varieties reputed to be very good in yield, aroma, taste, color, and fineness of veins were used.

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[1] Experiment Station contribution No. 1390.

[2] PAGUIRIGAN, D. B., AND P. TUGADE. 1935. Wrapper tobacco. Philippine Jour. Agric. 6: 1–114.

Review of literature

According to Stewart (1908), wrapper tobacco can be grown in the shade profitably in the Connecticut Valley if the grower obtains a good strain of seed and starts on a small scale until he gets some experience in handling the crop. Stewart states that the best cloth to use for shade is one with twelve hard twisted threads to the inch. He states further that to insure an abundance of good healthy plants, the seeds should be sterilized.

Paguirigan (1916-1917) is of the opinion that wrapper leaf tobacco can be grown successfully in the shade in the Philippines because there are certain regions which have all of the natural advantages for wrapper-leaf growing. The reason that tobacco growers fail to produce good wrapper tobacco lies in their failure to apply modern methods of growing the crop.

Paguirigan (1923) reports that Cuba produces first quality filler and high class wrapper because it possesses ideal climate and soil conditions for tobacco growing. The Cuban farmers apply commercial fertilizers to their tobacco fields on account of the yearly loss of soil fertility. He further states that in places in the Philippines where natural advantages exist, such as in the Cagayan Valley where a river overflows its banks yearly, tobacco farmers have a better chance of raising this kind of tobacco at less expense than elsewhere in this country.

Paguirigan (1924) reports that the best distance combination for Baker Sumatra is either 80 cm. x 50 cm. or 80 cm. x 40 cm. and for Florida Sumatra, 90 cm. x 50 cm. although the production of the former was much less than that of the latter.

Alvarado (1927) states that the difference in quality between the shade-grown wrapper tobacco and that grown in the open only a few feet away was most marked. He found that the leaves of that grown in the open were comparatively thick, whereas that grown in the shade had delicate veins, a fine, silky luster and were elastic and thin.

Gutierrez (1924) believes that certain regions of Cotabato Valley are favorable for the production of wrapper tobacco because the soil and climatic conditions are favorable. The planting distances which he found satisfactory were: Sumatra, 80 cm. between the rows and 40 cm. between the plants in the row, and Florida Sumatra, 90 cm. to 100 cm. between the rows and 50 cm. between the plants in the row.

Gutierrez (1927) reports that wrapper tobacco varieties grown at Sarunayan and Pikit Experiment Stations produced leaf tobacco which was considered by W. E. Olsen and Company, Manila as "the finest tobacco that was probably ever produced in the Philippine Islands". He further states that Baker Sumatra which was shaded produced good wrapper leaves. It gave 30 per cent of fine wrapper leaves, in the open, and 50 per cent in the shade whereas the Florida Sumatra, under similar conditions, produced up to 45 per cent of wrapper leaves.

Hernandez (1929) mentions the following essentials in cigar wrapper tobacco production. The variety must be suited to the place in order to produce the desired quality. The soil must be rich and of friable texture. The seedlings must have a uniform stand before transplanting. The shed must be spacious, rain-proof, and walled. The leaves must be completely cured in the shed. The plants should be distanced according to the Sumatra or the regular method. The distance of the Sumatra method is 50 cm. by 50 cm. with alternate furrows, 80 cm. wide. The regular method is 50 cm. by 60 cm. with alternate furrows, 80 cm. wide.

Objects of the work

The objects of the present study were: (*a*) to determine whether Vizcaya, Simmaba, Florida Sumatra, and Ilagan Sumatra tobacco varieties can be grown successfully in Los Baños, (*b*) to make a comparative study of their actual yield, and (*c*) to determine which of the four varieties most closely resembles the Sumatra wrapper in quality.

Time and place of the work

This study was conducted in the College of Agriculture, Los Baños, Laguna, from September, 1935, to January, 1937, covering a period of about sixteen months. The cultural operations were carried out in the tobacco field north of the Agricultural Botany Building, and the laboratory work was performed in the Tobacco and Cotton Laboratory of the Department of Agronomy.

MATERIALS AND METHODS

Varieties used

The tobacco varieties used in this study were Vizcaya, Simmaba, Florida Sumatra, and Ilagan Sumatra. The seeds of Vizcaya and Ilagan Sumatra were obtained from the Economic Garden of the

Bureau of Plant Industry, and those of Simmaba and Florida Sumatra were furnished by the Division of Tobacco and Cotton of the Department of Agronomy.

Land

Kind of soil. The soil of the field used in this study is clay loam. The field had been planted to tobacco for the past three years.

Area of lot. The area used for each variety was 323.43 square meters, or 1,293.72 square meters for the four varieties of tobacco studied.

Preparation of the seed bed

Petroleum boxes were sawed into halves and made into seed boxes. Each was provided with drainage by holes in the bottom. Sterilized gravel and coarse sand were placed at the bottom of the boxes. On top of the sand compost soil that had been sterilized previously on a galvanized iron sheet over an open fire for two and a half hours was added.

Sowing the seeds

Twenty parts of sterilized sand and one part of seed of each of the four varieties were mixed. The mixture was broadcast uniformly on the surface of the seed bed on October 15, 1935, and the seed bed was labeled with the varietal name. The seed beds were protected from ants and their soil was kept only moderately moist to prevent damping-off disease.

Pricking

On November 10, 1935, when the seedlings were about three centimeters above the surface of the soil, they were pricked at least eight centimeters each way in seed boxes to give them more space for proper development. After being pricked, they were put under a shed made of bamboo and cogon. Fifteen days later, the seedlings were gradually exposed to the sun to harden.

Preparation of the field

The field was first plowed with a tractor in the latter part of September, 1935, to destroy the weeds. After being allowed to fallow for about two months, it was plowed again with a tractor and harrowed on the following day. After ten days the land was plowed for the third time and harrowed.

After the soil was levelled, the field was divided into five plots, each with an area of 323.43 square meters.

Transplanting

One day before the seedlings were transplanted to the field, all the seed boxes were thoroughly watered to make the soil soft so as to facilitate the removal of the seedlings with a trowel and to minimize root injury. Only seedlings which were stocky and healthy were selected for transplanting. The seedlings were planted late in the afternoon on December 15, 1935.

The seedlings were set in rows 100 centimeters apart and in hills 75 centimeters apart in the row. They were watered at once and were not shaded for the weather was cool and cloudy for about a week.

Care of the culture in the field

Cultivation. Ten days after the seedlings had been set in the field, they were cultivated with a hoe. Subsequent cultivations were done at intervals of one week until the leaves of the tobacco plants were ready for harvesting.

Weeding. The weeds in the furrows were hoed down with a garden hoe, after the soil around the plants was cultivated. Weeding was done from time to time until the tobacco plants were about to bloom.

Replanting. Five days after the seedlings were set in the field, the missing hills were replanted with selected seedlings. The replanted seedlings were shaded.

Worming. All worms that attacked the tobacco were collected and destroyed. Worming was done every other day early in the morning or late in the afternoon. All eggs of insects that were seen on the leaves were likewise collected and destroyed.

Topping. As soon as the flower buds appeared, they were pinched off, and a few top leaves were left below the cut ends of the plants. The flower buds were cut off as they appeared because, in the production of wrapper tobacco, the goal is to produce leaves which are thin, elastic, light colored, and fine veined.

Before the plants in each of the four varieties were topped, one hundred plants were taken at random and set aside for study of the following varietal characteristics: (*1*) position and form of young and mature leaves, (*2*) average height and diameter of stems at blos-

soming time, (*3*) change of color of leaves, (*4*) thickness and size of sand, standard, and top leaves, (*5*) degree of gumminess, (*6*) freedom from spots, (*7*) resistance to pests and diseases, (*8*) thickness and lightness, and (*9*) elasticity and prominence of veins.

The position of young and mature leaves was recorded as horizontal, vertical, or drooping, and the form as oblong, ovate, elliptical, etc. The height and diameter of the stem of each of the selected plants were measured when the plants attained the flowering stages. The measurement of the height was taken on the stem from the surface of the ground to the highest point reached by the plant; the diameter was taken at the widest part, approximately ten centimeters above the ground.

The color of the young and mature leaves was noted as light green, green, dark green, or yellowish green. The size of the different classes of leaves produced from each variety was noted as small, medium, or large. The thickness of sand, standard, and top leaves of each of the four varieties studied was measured with a micrometer caliper at about the middle portion of each leaf. All leaves that were attacked by worms were separated from the sound leaves and were piled separately depending on the degree of damage suffered.

In determining the texture of the leaves harvested, nearly all the leaves from the plants were examined one by one. The degree of gumminess was determined by feeling with the fingers and with the use of a hand lens.

Suckering. Several days after the tobacco plants had been topped, suckers began to appear at the axils of the leaves. These suckers were pinched off as soon as they were about one inch long, at which time they were easy to remove, being soft and tender. The object of removing the suckers from time to time was to induce the tobacco to produce larger leaves.

Diseases and pests. Three diseases were found attacking the tobacco plants in the field. These were: tobacco wilt possibly caused by *Bacterium solanaccarum* E. F. S.; leaf spot, or frog's eye, caused by *Cercospora nicotianae* Ell. and Evht.; and the mottling and curling of the tobacco leaves.

Among some of the common pests attacking the plants were two long-horned grasshoppers, *Phaneroptera furcifera* Stål and *Hexacentrus munda* Walker; cricket, *Gryllus testaceus* Walker, *Prodenia*

litura Hübner, and *Plusia chalcytes* Esper; and stem borer, *Phthorimaea heliopa* Lower.

Harvesting

Harvesting was begun on February 15, 1936, or a little over eight weeks after transplanting. The leaves were gathered from time to time as they matured in the field.

When they began to turn pale yellow, they were harvested at once. Great care was exercised not to harvest them either too green or too ripe. The sand leaves were first harvested, and subsequent harvesting was extended to the uppermost leaves from time to time as they showed signs of proper ripeness. Since the leaves of each variety matured on different dates, there was no fixed date for harvesting.

All leaves harvested from one variety were kept separate and labeled accordingly so as not to mix them with those harvested from the other varieties studied. The harvested leaves were then taken to the curing house and were allowed to wilt for from twelve to twenty-four hours. The leaves were allowed to wilt before poling so as to prevent breaking of the petioles when the sharp pointed stick of bamboo or pole was pushed through them. Before being poled, the leaves were classified according to size, soundness, and the part of the plant from which they were harvested.

Poling

After being classified, the different grades of tobacco leaves were poled. The poles were strips of bamboo approximately one meter long and one centimeter wide. These poles are called "tudoc" in the Ilocano and Pangasinan regions, and "palillo" in the Cagayan Valley. Each strip was sharpened to a point at one end so as to facilitate the stringing of the leaves. The leaves were spaced two centimeters apart, throwing all of the midribs to one side and the laminae to the other side. All of the sand, standard, and top leaves of the different varieties studied were poled separately and labeled accordingly.

Curing

The old Hawaiian Insectary Building was used in curing the leaves of the different varieties of tobacco studied. The classified leaves of each variety were hung at uniform distances on wooden racks, and were left on these racks until they were completely dry.

During the curing process, the temperature inside the building was regulated by opening and closing the windows. Great care was exercised in drying the leaves slowly and gradually so as to fix in them a uniform light color, elasticity, good flavor, aroma, strength, and suppleness. When the leaves were thoroughly and completely dry, they were stripped off the poles preparatory to fermentation. Stripping was done when they were soft and slightly moist to prevent breaking their laminae.

Fermenting

After the leaves were stripped from the poles they were tied into small bundles. This was done very early in the morning, very late in the afternoon, or at the time when they were soft and elastic so as to minimize breakage. The leaves were then kept in closed containers to preserve their aroma and flavor.

The leaves of each variety were placed separately in a closed box. The sand, standard, and top leaves were kept separate and properly labeled. Each box was lined with thick Manila paper so as to conserve the volatile aroma and flavor of the leaves. The piles in the boxes were broken twice a month, and the leaves that were inside were put outside where they were repiled. The piling and repiling were continued for twelve months, after which five kilograms of the leaves of each variety were submitted to the Manager of the Alhambra Cigar and Cigarette Manufacturing Company, Manila for appraisal.

Weighing the fermented leaves

In December, 1936, the fermented leaves in the boxes were repiled for the last time. Separate weights of the fermented sand, standard, and top leaves from each of the four varieties studied were recorded. A five kilogram representative sample of each variety studied was packed separately and then taken personally to Alhambra Cigar and Cigarette Manufacturing Company for appraisal of color, aroma, flavor, elasticity, and burning quality.

RESULTS AND DISCUSSION

The results of this study are presented in tables 1 to 6.

Table 1 shows that the sand leaves of the variety Vizcaya were longer and narrower than its top leaves; the average length and width were 34.88 $\pm$ 0.29 cm. and 17.54 $\pm$ 0.13 cm., and 33.12 $\pm$ 0.50 cm. and 18.00 $\pm$ 0.30 cm., respectively. The standard leaves were

46.85 cm. long and 27.76 cm. wide. The leaves became thicker and more gummy as they appeared higher above the ground.

The variety Simmaba exhibited the same order of leaf characteristics as the Vizcaya, only that the leaves of the former were observed to be smaller than those of the latter, or 33.16 cm. long and 17.14 cm. wide for sand, 40.20 cm. and 27.98 cm. for standard, and 30.18 cm. and 17.20 cm. for top.

The leaves of the variety, Ilagan Sumatra, were found to be smaller than those of either Simmaba or Vizcaya. The top leaves of the variety Ilagan Sumatra were less gummy than those of either Simmaba or Vizcaya.

The leaves of Florida Sumatra variety were slightly larger than those of Ilagan Sumatra variety, or 38.35 $\pm$ 0.61 cm. long and 25.02 $\pm$ 0.36 cm. wide for the standard leaves of the former variety, and 37.35 cm. long and 25.02 cm. wide for the latter one.

Of the four wrapper varieties studied, Vizcaya had the largest leaves, and Ilagan Sumatra, the smallest. The standard leaves of the variety, Vizcaya, were found to be the thinnest and those of the variety, Simmaba, the thickest.

The average height and diameter of the stems of the four different varieties of wrapper tobacco studied are shown in table 2. The variety, Vizcaya, had the tallest and largest stems, 141.1 cm. high and 2.35 cm. thick, while the variety, Florida Sumatra, had the smallest stem, 87.3 cm. high and 1.59 cm. thick. The second largest variety, both in height and in thickness, was Simmaba. The differences in size of stem and leaves could not have been due to soil and climate, for they were grown in the same place and at the same time. These differences were mainly due to varietal characteristics, as shown in table 1.

Table 3 gives the position, form, and color of the young and mature leaves of each of the four varieties and it shows that they varied considerably. These differences among the leaves are probably due to varietal characteristics or varietal response as all plants were grown at the same time and on the same type of soil.

Of the four wrapper tobacco varieties studied, Ilagan Sumatra flowered the earliest; this was followed by Florida Sumatra (table 4). Simmaba was found to be the latest maturing variety. The sand, standard, and top leaves of each of the four varieties studied practically matured within the same corresponding dates.

Table 5 gives actual yield per 323.43 square meters of each of the four varieties studied: Vizcaya, 16.2 kgm.; Simmaba, 16.0 kgm.;

Ilagan Sumatra, 12.8 kgm.; and Florida Sumatra, 11.6 kgm. The corresponding computed yields per hectare were 508.88, 494.69, 395.75, and 358.65 kgm. The heaviest yielder was Vizcaya, and the lightest, Florida Sumatra.

Table 6 shows that Vizcaya was the best among the four varieties of wrapper tobacco studied. According to the Manager of the Alhambra Cigar and Cigarette Manufacturing Factory, this variety had a satisfactory color, pleasant aroma, good flavor, good burning quality, and fair elasticity. The other varieties studied were either mixed in color, lacking in aroma and flavor, or unsatisfactory in burning quality.

SUMMARY AND CONCLUSIONS

1. Of the four varieties studied, Vizcaya had the largest leaves and Ilagan Sumatra, the smallest.

2. The standard leaves of the variety Vizcaya, were found to be the thinnest and those of the variety Simmaba the thickest.

3. The Vizcaya had the tallest and largest stem, while the Florida Sumatra variety, the smallest.

4. Of the four varieties studied, Ilagan Sumatra matured earliest, followed by Florida Sumatra. Simmaba was found to be the latest maturing variety of all.

5. The Vizcaya was found to be the heaviest yielder and Florida Sumatra, the lightest.

6. Among the four wrapper tobacco varieties studied, Vizcaya was the best. This variety produced leaves with a satisfactory color, pleasant aroma, good flavor, good burning quality, and fair elasticity. The other varieties lacked uniformity in color, were poor in aroma, tasteless, and unsatisfactory in burning quality.

7. All of the four wrapper tobacco varieties studied were grown successfully under Los Baños conditions.

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TABLE 1

Green leaf characteristics of the different wrapper tobacco varieties studied

VARIETY	NO. OF LEAVES STUDIED	AVERAGE LENGTH	AVERAGE WIDTH	AVERAGE THICKNESS	DEGREE OF GUMMINESS
		centimeters	*centimeters*	*millimeters*	
Vizcaya	Sand leaves 100	34.88±0.29	17.54±0.13	0.230±0.001	Slightly gummy
	Standard leaves 100	46.85±0.01	27.76±0.50	0.216±0.001	moderately gummy
	Top leaves 100	33.12±0.50	18.00±0.30	0.256±0.001	Very gummy
Simmaba	Sand leaves 100	33.16±0.24	17.14±0.15	0.243±0.001	Slightly gummy
	Standard leaves 100	40.20±0.80	27.98±0.47	0.259±0.001	moderately gummy
	Top leaves 100	30.18±0.33	17.20±0.33	0.254±0.001	Very gummy
Ilagan Sumatra	Sand leaves 100	28.08±0.30	18.04±0.20	0.245±0.001	Slightly gummy
	Standard leaves 100	37.35±0.61	25.02±0.35	0.249±0.001	moderately gummy
	Top leaves 100	29.99±0.37	19.34±0.18	0.249±0.001	Gummy
Florida Sumatra	Sand leaves 100	31.63±0.26	19.80±0.20	0.239±0.001	Slightly gummy
	Standard leaves 100	38.35±0.61	25.02±0.36	0.251±0.001	moderately gummy
	Top leaves 100	28.90±0.18	17.08±0.21	0.253±0.001	Gummy

TABLE 2

Average diameter of stems at blossom time of Vizcaya, Simmaba, Florida Sumatra, and Ilagan Sumatra wrapper tobacco varieties

NAME OF VARIETY	NUMBER OF PLANTS STUDIED	AVERAGE HEIGHT	AVERAGE DIAMETER
		centimeters	*centimeters*
Vizcaya	100	141.1 ± 3.34	2.350 ± 0.03
Simmaba	100	121.9 ± 0.29	2.300 ± 0.03
Ilagan Sumatra	100	119.7 ± 0.27	1.976 ± 0.01
Florida Sumatra	100	87.3 ± 0.02	1.590 ± 0.01

TABLE 3

Position, form, and color of young and old leaves of the Vizcaya, Simmaba, Ilagan Sumatra, and Florida Sumatra tobacco varieties

ITEMS	VIZCAYA	SIMMABA	ILAGAN SUMATRA	FLORIDA SUMATRA
Position:				
Young	horizontal	horizontal	horizontal	vertical
Old	drooping	drooping	drooping	horizontal
Form:				
Young	elliptical	elliptical	ovate-orbicular	oblong elliptical
Old	elliptical	elliptical	ovate-orbicular	oblong elliptical
Color:				
Young	green	green	light green	green
Old	light green	light green	yellowish green	light green

TABLE 4

Dates of flowering of the four tobacco varieties[a] and harvesting of the sand, standard, and top leaves

ITEMS	VIZCAYA	SIMMABA	ILAGAN SUMATRA	FLORIDA SUMATRA
Harvesting				
Sand leaves	Feb. 15 and 20, 1936	Feb. 15 and 20, 1936	Feb. 16 and 21, 1936	Feb. 16 and 21, 1936
Standard leaves	Feb. 26 and March 2, 1936	Feb. 26 and March 2, 1936	Feb. 27 and March 3, 1936	Feb. 27 and March 3, 1936
Top leaves	March 9 and 15, 1936	March 9 and 15, 1936	March 10 and 17, 1936	March 10 and 17, 1936
Flowering	March 1, 1936	March 4, 1936	Feb. 24, 1936	Feb. 27, 1936

[a] Seeds sown on October 15, seedlings pricked on November 10 and transplanted on December 15, 1935.

TABLE 5

Actual yield per plot and computed yield per hectare of cured leaves

VARIETY	AREA PLANTED	ACTUAL YIELD			ACTUAL YIELD PER 323.43 SQ. METERS	COMPUTED YIELD PER HECTARE
		Sand leaves	Standard leaves	Top leaves		
	sq. m.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
Vizcaya	323.43	3.5	7.3	5.4	16.2	508.88
Simmaba	323.43	4.0	7.2	4.8	16.0	494.69
Ilagan Sumatra	323.43	3.4	7.2	2.2	12.8	395.75
Florida Sumatra	323.43	3.5	5.7	2.4	11.6	358.65

TABLE 6

Quality of the cured leaves produced from each variety

ITEMS	VIZCAYA	SIMMABA	ILAGAN SUMATRA	FLORIDA SUMATRA
Color	satisfactory	mixed	greasy, not uniform	light but reddish
Aroma	pleasant	lacking	fair	fair
Flavor	good	tasteless	raw	good
Burning quality	good	good	unsatisfactory	good
Elasticity	fair	fair	fair	brittle

COLLEGE AND ALUMNI NOTES

The issue of *Foreign Agriculture,* Volume IV, No. 7, July, 1940, page 420, published by the Foreign Agricultural Relations, United States Department of Agriculture, Washington, D. C. contains the following item:

> "The agricultural college at Los Baños has been in operation since 1907 and furnishes a good standard of agricultural training. The aim of the college from the beginning was to give collegiate instruction in agriculture; but the need for experimentation and research was soon realized, and in 1915 the agricultural experiment station was established as an adjunct to the college. Research in connection with teaching expanded rapidly, and the staff of the college and experiment station have made many contributions to the science of agriculture."

Capt. George T. Plummer entertained a big audience, consisting mostly of faculty and students, with an illustrated lecture on the life of the Eskimo. The Program, held at Baker Memorial Hall on August 17, was sponsored by the College Committee on Drama and Music.

Dr. H. Tauber of the University of Prague, Austria, visited the campus on August 14 and 15. He collected plankton from Laguna de Bay and insects from Mount Maquiling.

Dr. Otto A. Reinking, the first professor of plant pathology and head of the Department of Plant Pathology of this College and now head of the Department of Plant Pathology of the New York Agricultural Experiment Station at Geneva, was married to Miss Addie Pieh on July 22, 1940, at Winchester, Virginia.

Mr. Tsui Kwok Hing, who obtained his Master of Science degree in botany in 1940, was married to Miss Sung Shuk Ying at Macao on September 1. Mr. Tsui is at present assistant professor of botany in Lingnan University.

Dr. E. D. Lucas, professor of agricultural economics of the Punjab University, India, visited the Department of Agricultural Economics of the College on September 4. He was primarily inter-

ested in village life. Professor J. E. Velmonte presentd the visiting economist with publications of the department on standards of living of rural families.

The following papers were read and discussed at the regular meeting of the Los Baños Biological Club on September 5, 1940:

Prof. A. B. Catambay and Mr. S. Kulthongkam. The use of alcohol as a fuel for farm engines.

Dr. F. M. Fronda. A report on a trip to Australia and New Zealand.

Mr. José K. Demeterio, a University fellow who did graduate work in agricultural chemistry at the University of Louisiana, sailed from San Francisco on September 6 on S.S. "President Cleveland" for the Philippines.

Dr. Julian Banzon returned to the College on September 3 after an absence of three years in the United States as a University fellow. He pursued graduate work in agricultural chemistry at the Iowa State College of Agriculture and Mechanic Arts where he recently received his degree of Doctor of Philosophy. During his residence at Ames, Iowa, he was accorded recognition by his election to the honor societies of Sigma Xi, Phi Kappa Phi, Phi Lambda Upsilon, and to fellowship in the American Association for the Advancement of Science.

Mr. Segundo Labayen '15 has been promoted lately to the position of resident manager of the Binalbagan Sugar Estate in Occidental Negroes, the first Filipino to occupy that important post in one of the biggest sugar estates in the Philippines. After graduating from this College, Mr. Labayen took a post graduate course in Audubon Sugar School, Audubon, Louisiana. He was successively central chemist and superintendent of fabrication for many years at Binalbagan.

THE EXPERIMENT STATION

LIST OF AVAILABLE CIRCULARS

Circular No. 2.—Bud Rot of Coconut (Revised, June, 1934) - - - *By G. O. Oefemia*

Circular No. 3.—Experimental Errors and Application of the Probable Error to and the Interpretation of Experimental Results - - - - - - - - - - - - *By Nemesio B. Mendiola* (Published as Chapter IV in *A Manual of Plant Breeding for the Tropics*, 1926, also sold by THE PHILIPPINE AGRICULTURIST at ₱3.25, paper bound, and ₱5.25, cloth bound, in the Philippines, and ₱3.50 and ₱5.50 elsewhere, postpaid.)

Circular No. 5.—Poultry Raising Made Easy (Revised) - - - - *By F. M. Fronda*

Circular No. 7.—How to Produce New Varieties of Gumamela (Hibiscus) - - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 8.—Horse Breeding in the Philippines - - - - - *By Valente Villegas*

Circular No. 9.—Fences for Farm Animals - *By B. M. Gonzalez and J. P. Esguerra*

Circular No. 10.—Practical Directions for Coffee Planting - - - *By Pedro A. David*

Circular No. 11.—The New College Copra Drier—Prepared in *Department of Agricultural Chemistry* with cooperation of *Department of Agronomy and Extension.* (Revised by *Moises M. Kalaw*).

Circular No. 14.—Beriberi: Its Causes and Prevention - - - - - *By F. O. Santos*

Circular No. 15.—Cattle Raising under Philippine Conditions - - *By Valente Villegas*

Circular No. 16.—A Simple Farm Record for the Farmer - - *By Francisco M. Sacay*

Circular No. 17.—College Trapnest - - - - - - - - *By F. M. Fronda and P. S. Paje*

Circular No. 18.—Surveying for Area with a Surveyor's Staff - *By Alexander Gordon*

Circular No. 19.—A Pageant: Illustrating the History and Growth of the College of Agriculture - - - - - - - - - *By Anne F. Cole*

Circular No. 20.—Amount of Nutrients in Philippine Food Materials - - - - - - - - - *By F. O. Santos and S. J. Ascalon*

Circular No. 21.—Cassava Growing and Cassava Starch Manufacture - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 22.—Goat Raising - - - - - - - - - - - - - - *By Valente Villegas*

Circular No. 23.—Curing Pork and Making Sausage for Home Use - - - - - - - - - - - - - - - *By Mariano Mondoñedo*

Circular No. 24.—Construction and Operation of Silos in the College of Agriculture - - - - - - - - - - - - *By José P. Esguerra*

Circular No. 26.—Training Cattle and Carabaos for Work - - - *By Valente Villegas*

Circular No. 27.—Bunchy-top of Abacá - - - - - - - - - - - - *By G. O. Oefemia*

Circular No. 28.—Cotton Culture - - - - - - - - - - - - *By Eulalio P. Baltazar*

Circular No. 29.—Collegiate Education in Agriculture - - - - *By L. B. Uichanco*

Circular No. 30.—What Should Filipino Ornamental Gardens and Ornamental Plants Be? - - - - - - - - - - *By N. B. Mendiola*

Circular No. 31.—How to Slaughter and Dress Farm Animals - - - - - - - - *By Valente Villegas and M. Mondoñedo*

The Circulars Nos. 1, 3, 4, 6, 12, 13, and 25 are out of print.

The price of the Circulars listed above is 10 centavos each except Nos. 5, 10, 16, 21, and 30 the price of which is 20 centavos.

ALL ORDERS SHOULD BE ADDRESSED TO THE BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST, AGRICULTURAL COLLEGE, LAGUNA, PHILIPPINES